DOCUMENT RESUME

ED 254 195 IR 011 507

TITLE	The Computer Literacy Act, H.R. 3750 and The National Educational Software Act, H.R. 4628. Hearing before the Subcommittee on Science, Research and Technology of the Committee on Science and Technology, House of Representatives, Ninety-Eighth Congress, Second Session, June 5, 1984. No. 107.
INSTITUTION	Congress of the U.S., Washington, D.C. House Committee on Science and Technology.
PUB DATE	84
NOTE	353p.
PUB TYPE	Legal/Legislative/Regulatory Materials (090) -- Viewpoints (120) -- Reports - Descriptive (141)
EDRS PRICE	MF01/PC15 Plus Postage.
DESCRIPTORS	*Access to Education; Computer Assisted Instruction; *Computer Literacy; Computers; *Computer Software; Federal Legislation; Futures (of Society); Hearings; *Policy Formation; Public Policy; *Teacher Education
IDENTIFIERS	*Computer Uses in Education; Congress 98th

ABSTRACT

This legislative report offers testimony and related materials concerning two bills that address the issues of the computer in the classroom as an educational tool, access to computers, teacher training, and software development through the establishment of a National Computer Educational Software Corporation. Testimony of the following witnesses is included: Representatives Albert Gore, Jr. (Tennessee), Timothy E. Wirth (Colorado), and Thomas J. Downey (New York); Gary Bauer, Department of Education; Richard S. Nicholson, National Science Foundation; Roy Truby, Council of Chief State School Officers; Linda Tarr-Whelan, National Education Association; Sue Talley, Apple Computer Corporation; Paul Horwitz, Bolt, Beranek, and Newman, Inc.; Lois Rice, Control Data Corporation; Harry McQuillen, Columbia Broadcasting System, Inc.; Sherry Turkle, Massachusetts Institute of Technology; Fredrick Bell, University of Pittsburgh; and F. James Rutherford, American Association for the Advancement of Science. Additional testimony submitted for the record includes that of the Association of American Publishers, Inc.; Association of Data Processing Service Organizations; T. H. Bell, Secretary of Education; and George A. Keyworth, Science Advisor to the President. (LMM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

IR

H.R. 3750, THE COMPUTER LITERACY ACT AND H.R. 4628, THE NATIONAL EDUCATIONAL SOFTWARE ACT

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

ED254195

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

SECOND SESSION

JUNE 5, 1984

[No. 107]

Printed for the use of the
Committee on Science and Technology

IR011507

37-927 O

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1984

COMMITTEE ON SCIENCE AND TECHNOLOGY

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
GEORGE E. BROWN, Jr., California
JAMES H. SCHEUER, New York
RICHARD L. OTTINGER, New York
TOM HARKIN, Iowa
MARILYN LLOYD, Tennessee
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
ALBERT GORE, Jr., Tennessee
ROBERT A. YOUNG, Missouri
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
STAN LUNDINE, New York
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
MERVYN M. DYMALLY, California
PAUL SIMON, Illinois
NORMAN Y. MINETA, California
RICHARD J. DURBIN, Illinois
MICHAEL A. ANDREWS, Texas
BUDDY MacKAY, Florida
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
ROBERT G. TORRICELLI, New Jersey
FREDERICK C. BOUCHER, Virginia

LARRY WINN, Jr., Kansas
MANUEL LUJAN, Jr., New Mexico
ROBERT S. WALKER, Pennsylvania
WILLIAM CARNEY, New York
F. JAMES SENSENBRENNER, Jr., Wisconsin
JUDD GREGG, New Hampshire
RAYMOND J. McGRATH, New York
JOE SKEEN, New Mexico
CLAUDINE SCHNEIDER, Rhode Island
BILL LOWERY, California
ROD CHANDLER, Washington
HERBERT H. BATEMAN, Virginia
SHERWOOD L. BOEHLERT, New York
ALFRED A. (Al) McCANDLESS, California
TOM LEWIS, Florida

Harold P. Hanson, *Executive Director*
Robert C. Ketcham, *General Counsel*
Regina A. Davis, *Chief Clerk*
David S. Jeffery, *Minority Staff Director*

Subcommittee on Science, Research and Technology

DOUG WALGREN, Pennsylvania, *Chairman*

GEORGE E. BROWN, Jr., California
DAVE McCURDY, Oklahoma
MERVYN M. DYMALLY, California
NORMAN Y. MINETA, California
BUDDY MacKAY, Florida
ROBERT G. TORRICELLI, New Jersey
STAN LUNDINE, New York
PAUL SIMON, Illinois
RICHARD J. DURBIN, Illinois
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
FREDERICK C. BOUCHER, Virginia

JUDD GREGG, New Hampshire
SHERWOOD L. BOEHLERT, New York
F. JAMES SENSENBRENNER, Jr., Wisconsin
RAYMOND J. McGRATH, New York
JOE SKEEN, New Mexico
HERBERT H. BATEMAN, Virginia

CONTENTS

WITNESSES

June 5, 1984:

Page
- Hon. Albert Gore, Jr., Member of Congress from Tennessee 3
- Hon. Timothy E. Wirth, Member of Congress from Colorado 6
- Hon. Thomas J. Downey, Member of Congress from New York 13
- Gary Bauer, Deputy Under Secretary for Planning, Budget, and Evaluation, Department of Education 40
- Dr. Richard S. Nicholson, Acting Deputy Director, National Science Foundation 55
- Dr. Roy Truby, superintendent of schools, West Virginia, representing the Council of Chief State School Officers 80
- Dr. Linda Tarr-Whelan, director of Government relations, National Education Association 101
- Sue Talley, education program development manager, Apple Computer Corp. 125
- Dr. Paul Horwitz, Bolt, Beranek, and Newman, Inc. 137
- Lois Rice, senior vice president, Control Data Corp 150
- Harry McQuillen, president, CBS Educational and Professional Publishing, CBS, Inc. 164
- Dr. Sherry Turkle, professor, program in science, technology, and society, Massachusetts Institute of Technology 253
- Dr. Fredrick Bell, professor, mathematics and computer education, University of Pittsburgh 311
- Dr. F. James Rutherford, chief education officer, American Association for the Advancement of Science 320

APPENDIX

Additional testimony submitted for the record:

- Association of American Publishers, Inc 339
- Association of Data Processing Service Organizations 344
- Departmental Views on H.R. 3750 and H.R. 4628 submitted by T.H. Bell, Secretary of Education 347
- Views of H.R. 4628, National Educational Software Act of 1984, by George A. Keyworth, Science Advisor to the President 349

H.R. 3750, THE COMPUTER LITERACY ACT, AND H.R. 4628, THE NATIONAL EDUCATIONAL SOFTWARE ACT

TUESDAY, JUNE 5, 1984

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The subcommittee met, pursuant to call, at 9:45 a.m., in room 2325, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Members present: Mr. Walgren, Mr. Mineta, Mr. Brown, Mr. Valentine, and Mr. Bateman.

Mr. **Walgren**. Let us come to some kind of general order.

Computer technology, as most in this room know, penetrates nearly every nook and cranny of our lives and because the computer is a general purpose device for processing information, there are few areas of human endeavor which cannot be enhanced through the use of that machine. What we will consider today is use of the computer in the classroom as an instructional tool.

According to an October 1983 survey, there are about 350,000 microcomputers in use in our schools, suggesting that approximately 54,000 schools are now using microcomputers for use in the classroom. However, numerous organizations, individual teachers, administrators and parents, as well as the media, have pointed to the many problems involved with bringing computers to the schools.

First, the limitations of the educational software now available are substantial. Last year, Secretary Bell, in testimony before the Investigations and Oversight Subcommittee of the Science and Technology Committee, characterized today's software as "simple electronic page-turning programs." Although progress has been made in learning, cognition, and psychology research, little of the findings have found their way into commercially available educational products.

We are in that sense about through our basic research to find knowledge that will literally explode in the educational area through the use of computers in the near future.

Second, although our children may be computer whizzes, the other side of that coin is that they have in many cases outpaced their teachers and their parents, and the problem of keeping teachers up with students in this area will be certainly a major challenge to our educational system. If we fail in that, the potential of this new technology certainly will not be realized to the degree that we would hope.

There is evidence that the haves are doing better than the have-nots, and particularly so when it comes to computers. About 60 percent of the poorer schools have no computers at all, whereas some 75 percent of those schools that we would classify as the richest in our society do have access to computers for student use.

There is also evidence that poorer schools are more likely to use the computers as simple drill and practice machines instead of integrating them into the broader classroom curriculum. The problem of balance in our system and being sure that each of the students that come through our society have the maximum opportunity to develop is one that we should certainly be concerned about.

The committee has before it two proposed bills which address these issues: H.R. 3750 and H.R. 4628. They have each been considered and marked up by the Committee on Education and Labor, and with referral to the Science and Technology Committee. We will be particularly interested in hearing as full comment as we can on those bills. Our witnesses' views of the need for teacher training, the need and the proper relationship between the Federal Government with respect to both hardware and software and how these proposed pieces of legislation meet and balance those needs.

I would like to turn to the gentleman from California, Mr. Mineta, for any opening comments he might wish to make.

Mr. MINETA. Thank you, Mr. Chairman.

I would like to thank our distinguished colleagues for appearing today on this panel. I am a cosponsor of the Computer Literacy Act and welcome the attention being paid to this bill as well as to the legislation to establish a National Educational Software Corporation.

My congressional district includes a part of Silicon Valley where much of the high tech industry was pioneered and remains today. I can readily remember when Silicon Valley was mostly farmland and scientists and entrepreneurs worked from their kitchen tables and their garages. It wasn't until the 1960's—just 20 years ago—that semiconductor research stopped being rare and arcane.

This makes me keenly aware of just how rapidly the computer industry has developed in this country. Moreover, because I spend a considerable amount of time visiting many of the high tech firms, I am constantly made aware that a new generation of equipment is in the offing with capabilities almost beyond our imagination.

Given this rapid rate of development, however, it is not inconceivable that progress in the industry would outpace the skills and talents of potential users. With the kind of incentives set forth in the legislation under consideration today, we would be building on a natural link between education and technology.

Age-old classroom subjects such as reading, math, science, and even logic can be taught in new and creative ways. Simultaneously accessibility to computers demystifies them and makes them less a novelty and more a normal and natural tool for learning and for working. In the long run, we would be preparing the next generation to be at ease with computers, to realize their potential and to welcome new technology with all its promise and rewards.

Again, I thank my colleagues for appearing before this committee today and thank you for the chance to express my thoughts.

Mr. **Walgren**. Thank you, Mr. Mineta.

We welcome today three Members of Congress who have a long and internal interest in education and particularly the cutting edges of education: Tim Wirth from Colorado; Al Gore from Tennessee; and Tom Downey from New York. I know that all of you have worked in concert and we salute the progress that your legislation has made thus far, each of your individual pieces of legislation, and want to work with you to try to give some life to what can be done in this area.

So we welcome you to the committee. I don't know how they set the order, it probably doesn't matter, so why don't we start with Al at the outset. If you would like to proceed.

STATEMENT OF HON. ALBERT GORE, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TENNESSEE

Mr. **Gore**. Thank you, Mr. Chairman.

As a fellow member of this Science and Technology Committee, I am grateful to you and this subcommittee for holding this hearing and I am grateful for Mr. Mineta's attention and comments this morning as well.

I believe we must rapidly accelerate the speed with which our young people are learning to use computers and using computers to learn. Hardware must be placed in the schools, adequate training must be provided to teachers, and a whole new generation of computer educational software must be developed to adequately integrate this new technology into all curricula.

I believe that my bill, which establishes a National Computer Educational Software Corporation, and those of my colleagues, Mr. Wirth and Mr. Downey, will help accelerate this transition. The result should be improved education opportunities for all students, regardless of economic status, enhanced job prospects for our young people entering a rapidly changing economic environment, and a national improvement in productivity and international competitiveness.

The potential for computers to improve education is enormous—more dramatic than any invention since writing. Yet that potential is not being met today. Last September the Science and Technology Subcommittee on Investigations and Oversight, which I chair, held 2 days of hearings on the issue of computers in education and I would like to share with this subcommittee copies of the hearing record that we compiled back in September, and what we learned during those hearings was extremely interesting.

Basically, there are three problems. They are fairly well known by now. The first is that the hardware is not yet widely available in the schools, especially in the lower grades, and that equipment which is available is not equitably distributed.

Second, teachers are not being adequately trained in how to use computers and to plan for their integration into standard course work.

Third, and in my view most importantly, high-quality educational software is almost nonexistent in our primary and secondary schools. It is this third problem that H.R. 4628 is designed to address.

My bill does not address the first two problems. The first two problems have to be solved and my colleagues, Mr. Wirth and Mr Downey, have imaginative approaches which I recommend to the subcommittee on those matters.

The third problem, involving high-quality educational software is the part of the problem which my bill seeks to address.

The Secretary of Education, Dr. T.H. Bell, made perhaps the most revealing statement during our hearing on this issue. He testified that practically all of the educational software now available consists of no more than electronic page-turning exercises, low-level, drill-and-practice programs; that many academic disciplines have virtually no software programs; and that incompatibility of different software and hardware language systems threaten any improvement in what is acknowledged to be a haphazard use of educational computer tools.

Secretary Bell followed up with a letter this year, which I will provide to the subcommittee, where he says, "I am extremely concerned about the current computer learning programs and the poor quality of computer software now available."

Now the administration, I am sure, will be expressing a somewhat different view in line with its general approach on issues of this kind, but I want the subcommittee to be fully aware that at the time they looked at this problem closely, they were certainly acknowledging that there is an extremely serious problem which is not being solved and which should be involved. Further complicating this problem is the widely diffused uneven marketplace which is essentially made up of thousands of necessarily unconnected local school systems.

Local educators and administrators are legitimately wary of investing large sums of local school budgets in computer technology, only to discover that the only software available is the lowest common denominator. Different brands of hardware—with completely different operating system languages—are often found even within the same school. As a result, where good programs exist, it is difficult and expensive to translate them into different formats.

An administration spokesman recently attempted to restate Secretary Bell's eloquent description of this problem, saying that if there is a problem, that the Government already has the tools to stimulate more software production.

Mr. Chairman, if that is the case, I ask the administration, "Where is it?" It is certainly not in the Memphis, TN, school system, where school administrators are scraping together a budget for computers, but complain that high-quality teaching software simply is not available. It is not to be found anywhere else in Tennessee, either. And the whole country faces the same problem.

Simply put, our schools are being swept up in a tidal wave of technology without any idea of how to make wise use of it.

Mr. Chairman, my bill is designed to make a modest but hopefully a significant improvement in the availability of educational software. It establishes a National Educational Software Corporation, made up of Government and private corporate and institutional representatives. The corporation would have the authority to provide venture capital support to high-quality, interactive educational software projects which have great promise but inadequate private funding.

These software ventures would be expected to provide the corporation a return on its investment, with profits made available for new projects. In that regard, we would expect the government support to set up the corporation—with $15 million in H.R. 4628—to become a revolving fund and essentially have a zero cost.

The educational benefit from this modest investment should be enormous, in the form of innovative new computer tools for teachers and students throughout the country. Eventually, over a long period of time, the marketplace will sort out this problem. The question facing this subcommittee and this Congress is whether or not the benefits to the Nation of accelerating the transition and speeding up the time at which these new educational software programs become available is a desirable national goal.

In light of our Nation's extreme interest in rapidly improving our educational system, I think clearly the goal is worth the effort. The corporation envisioned in my bill is based on a model begun several years ago by the Massachusetts Legislature, which set up the Massachusetts Technology Development Corp. to stimulate new high technology companies and new ventures in that State. The Massachusetts corporation has been a phenomenal success, with 22 profitable projects out of 22 ventures. I worked closely with one of the original board members of the corporation, Joe B. Wyatt, who is now chancellor of Vanderbilt University in Nashville, to develop H.R. 4628, the bill now before this committee.

We have a sound precedent for a modest Government participation in what is essentially a private undertaking. The Massachusetts success story is documented in our subcommittee report, and I encourage the members of this subcommittee to review that material.

Finally, let me review the relevant points in this discussion:

One, computers have an enormous potential for improving education, but there is a severe lack of availability of high-quality, interactive computer educational software.

Two, the market system to develop educational software is laboring under circumstances which make widespread development of new high-quality software difficult if not impossible in the short term.

Three, Federal support to software publishers in the form of grants or contracts has many flaws—lengthy startup problems and other bureaucratic roadblocks which stifle private software production.

Four, H.R. 4628, which establishes a National Computer Educational Software Corp., has a sound, successful precedent in the Massachusetts Technology Development Corp., as a modest approach to stimulating private investment in technology.

Mr. Chairman, I look forward to working with you and the members of the subcommittee to carefully examine the issues surrounding computers in education and look forward to working with you to solve these problems and I appreciate your attention this morning.

Mr. WALGREN. Thank you very much.

STATEMENT OF HON. TIMOTHY E. WIRTH, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF COLORADO

Mr. WIRTH. Thank you very much, Mr. Chairman.

I have a statement which I would like to submit in full in the record, if I might.

Mr. WALGREN. Without objection.

Mr. WIRTH. I am delighted to be here this morning with my distinguished colleagues and you and Congressman Mineta, who have sponsored H.R. 3750 which is endorsed by the American Association of School Administrators and the Rural Education Association. I need not tell you about the rapidly changing nature of our economy and the expectations that we have in the future for the participation of young people in that economy and the training that they need.

Unhappily, we are seeing a generation for the first time in our Nation's history that is less literate than its parents, less capable of manipulating ideas and numbers, and the two pieces of legislation before you will attempt to address that severe problem.

Let me discuss briefly H.R. 3750 and the substance of that legislation.

Essentially, there are three titles to the legislation, one on the supply of hardware to schools; second, the training of teachers; and third, the software issue.

On the first, as you pointed out in your opening statement, there are currently approximately 325,000 computers in the Nation's public schools. If we were to have available to every student in the country one-half hour per day of computerized instruction, computer-related instruction, we would need four million computers in the Nation's schools, or approximately 12 times the number we have today, and that is just for a formal, identified one-half hour.

If, in fact, we wanted to have available to students the ability to have computers there to use in off hours, to use in study-hall time, to use after school, 4 million computers would not begin to do the job. Four million provides just one-half hour per day instruction for the students in the Nation's public school system. In addition, unless we move aggressively, we are going to see increasingly a gap between rich and poor, an information gap and an education gap that has haunted our country for too long, which is being exacerbated by the policies of the administration and which will make young people in this country even less capable of participating in our economy and in our society as a whole.

So the first title is focused on providing that kind of hardware that is necessary to meet the educational needs and to help to bridge that critical gap between the rich and poor.

The second title of H.R. 3750 goes back to the history that we bitterly learned during Title I of the sixties. I had the privilege of managing that program for 2 years in the old Department of HEW. As we evaluated that program, it was clear that as all kinds of teaching technology was coming into the Nation's public schools, we didn't know how to use it. There were warehouses filled with projectors and audiovisual aids purchased with title I funding, but the curriculum had not been developed and teachers had not been trained to take advantage of these new technologies.

Title II of this bill is built upon that bitter lesson and built upon what we learned how to do during the sixties: to train and retrain teachers. We do know how to train and retrain teachers and that is what title II of the legislation is focused on.

I see we have a high-tech operation going this morning in terms of the sound system as well.

The third title addressed by Mr. Gore in his imaginative bill, H.R. 4628 is addressed in Congressman Downey's and my title III, and it seems to me there is a way to put the two together. On the software issue, we focused on use of the National Institute of Education through contracts to evaluate the availability of software and availability of computer systems so we don't reinvent the wheel. There is a central body of knowledge as to what works and what doesn't work.

I will touch upon what I think are the four main issues raised in the legislation.

First, the so-called Apple bill which may be before the Congress in the conference report in the Committee on Ways and Means. The Apple bill, through tax credits, allows school systems to have available to them computers. That does not address the problem of rich and poor. It really focuses on the funding and the tax credits on schools from more affluent districts. That is the fundamental problem with the Apple bill.

The second issue raised is why doesn't the present math and science education legislation do the job. As you will remember, that legislation was passed by this committee and the Committee on Education and Labor last year and awaits the movement in the Senate to realize the virtue of that legislation. Unhappily, that bill allocates only $5 million to this issue and is fundamentally a science and math education bill and does not go into the issue of computers.

Third, the administration's position will be, "I am sure this is important, but let's not do it now." Let me again remind the committee that if in fact we took just a small percentage of the amount of money that this administration is spending on antisatellite warfare and ballistic missile defense, Star wars, a small percentage of that money and invested it in our young people, we would be far ahead of where we are today.

It seems to me that we have to dismiss once and for all the nonsensical argument that "This is important, but let's not do it now." There is an argument raised relating to the National Institute of Education writing the software or getting into the publishing business. The NIE charter is clearly one of evaluating all kinds of materials, all kinds of curriculum. That is what the NIE in part was set up to do.

In our legislation, H.R. 3750, we are not asking the NIE to get into the software publishing business, but rather through contract to make available the kind of evaluation that can be used by school systems that would be done in the private sector, but the funding for that would be made available by contract from NIE. So it seems to me the argument that what we are doing is competing with the publishing business and getting the government into the publishing business is not borne out by a careful reading of the legislation.

I appreciate being here with my two colleagues, Mr. Gore and Mr. Downey. We have been working together on the legislation and look forward to working with you and hope that we can expedite movement of this.

[The prepared statement of Mr. Wirth follows:]

Mr. Chairman: I would first like to thank you and the members of your subcommittee for holding this hearing on the Computer Literacy Act of 1984 and would also like to thank the members of this subcommittee who have shown their support by cosponsoring this legislation.

Mr. Chairman, our nation is undergoing a profound transformation. The industrial society is quickly being replaced by the information society, with significant and far-reaching implications for our future. As part of this transformation, the computer is quickly becoming a common part of the lives of many Americans. As the report recently released by the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine entitled High Schools and the Changing Workplace: The Employer's View noted, "The computer may...pervade our society as widely and as decisively as the automobile did, and bring about changes just as profound." One need not look far to see evidence of this.

- A rapidly growing number of colleges and universities across the country are requiring students to purchase computers just as they are required to purchase classbooks.
- Basic computer skills are becoming a prerequisite for a large number of jobs in our economy as the computer becomes as common a piece of office equipment as the typewriter.
- The number of computer-related jobs has been estimated to rise to 30 million by 1990.

High Schools and the Changing Workplace concluded that there are certain core competencies needed by today's students in order to succeed in employment. The report recommended that familiarity with computers be included in one of these core competencies, a firm grounding in science and technology. Computer familiarity includes acquiring knowledge of the basic functions of computers, knowing what they can and cannot do, and understanding the possibilities and limits of frequently used software packages.

This evidence points to the conclusion that in order to participate fully in our economy, students must have access to computer technology. Yet, as Computers in Education, a report on a research conference sponsored last year by the Department of Education, concluded, "We appear to be raising a generation of Americans many of whom lack the understanding and the skills to participate fully in the technological world in which they live and work." There are only 325,000 computers for America's 40 million public school students, roughly one computer for every 123 students. If every child in our schools was to be provided 30 minutes a day on computers, we would need four million in the schools, twelve times the actual number.

Just as alarming is the disparity that is becoming increasingly evident when one looks at which students have access to computers. Recent surveys indicate that the ratio of wealthy students per computer is roughly 97 students per machine. However, among our nation's poorer students, the ratio is one computer per 183 students. This trend threatens the development of a class of technical illiterates who will be shut out of participation in our economy.

In addition to these concerns, we must not lose sight of the potential academic benefits of computer-based instruction. Initial research indicates that learning through the use of computers can significantly improve the academic performance of students. Computers allow students to experiment and be more creative, to perform calculations more quickly, and provide for a more individualized learning atmosphere. Moreover, studies are showing the tremendous potential computer-learning has for handicapped students.

The problem of computer literacy is much broader, however, than simply furnishing schools with computers. As we learned in the 1960's, providing schools with new technology without insuring that teachers know how to use the equipment effectively wastes taxpayers' money and passes over significant learning possibilities. In addition, a concern voiced by virtually every education official who has addressed the issue of computer literacy is the lack of quality software and the difficulty of obtaining information on what computer hardware and software would best meet an individual school's needs.

Several bills have been introduced on the issue of computers in the classroom, but none deal with the problem in a comprehensive way. Some are limited to providing schools with hardware, without addressing the teacher training, software or equity problems. Others deal only with the software concerns. In order to prepare our students fully for participation in the economy and in order to maximize the teaching potential of computers, the federal effort must be a comprehensive one. If we attack the problem in a piecemeal way, precious dollars and opportunities will be wasted.

The Computer Literacy Act of 1984 is a comprehensive solution to the problem. Title I would provide schools with the funds to purchase computer hardware. This money would be spread evenly throughout our nation's schools so that every student will have access to the equipment, with priority going to schools with the greatest need. A direct grant approach, rather than providing tax incentives to corporations who choose to donate computers to schools, was chosen as the most efficient and effective means to achieve these educational objectives. Specifically, the tax code approach provides no assurances schools in poorer districts would have the same access to such equipment as would schools in wealthier districts, and there is no guarantee that schools would obtain equipment best suited to their educational needs. Furthermore, a tax code approach does not address the remaining issues of teacher training, information sharing and lack of quality software.

Title II would establish teacher training institutes to instruct teachers in the use of computers. These institutes are modeled after those created by H.R. 1310, the emergency math and science legislation which this Committee approved last year. In H.R. 3750, non-profit scientific or engineering organizations, science museums, regional science education centers and State educational agencies would be eligible to provide this training in addition to institutions of higher education.

Title III would encourage the development of model courseware, as well as call upon the National Institute of Education (NIE) and the National Science Foundation (NSF) to provide grants or contracts to evaluate existing hardware and software and to disseminate this information to our nation's schools. This title as it was reported out of the Education and Labor Committee represents aspects of my original bill as well as legislation introduced by my colleague, Mr. Downey, which created Centers for Personal Computers in Education. Mr. Downey's bill contained several specific research functions these centers were to perform, outlining in more effective and specific detail the objectives of any effort to improve the sharing of information. These research functions have now been included in H.R. 1310, improving the third title of the legislation. I want to thank Mr. Downey for his help in improving H.R. 3750 and for his efforts on behalf of computer literacy.

I would like to make clear that our intention in this title was not to have the federal government write educational software, which would be similar to the federal government writing textbooks. This would not only overstep the federal government's lines of responsibility for education, but it would also be bad educational policy. Instead, what we hope to accomplish through Title III is a fostering of communication and sharing of information between the educational community and the business community. NSF and NIE should focus on such questions as how best to use the new technology and what software qualities make for an effective learning experience, but not such activities as listing the manufacturers considered to make quality software or producing a list of criteria software manufacturers must meet in order to be considered effective. The objective here is to provide a link between the education and business community, so software producers can understand what is needed by educators and so educators can understand the hurdles software producers face in creating educational software. Only through this kind of communication will teachers and students have the software needed for a productive learning experience.

Finally, the third title of this bill would establish model adult training programs in which computers, when not being used by students in the afternoons after school is out, can be used to teach adults and prepare today's workers for an economy that will soon be upon us.

This legislation has broad support, having been cosponsored by over 80 members of the House and endorsed by the National Education Association, the PTA, the American Association of School Administrators and the Rural Education Association.

In closing, I would like to again thank the subcommittee for its attention to this issue and for holding this hearing, and I would be happy to respond to any questions you may have.

Mr. WALGREN. Thank you.
Congressman Downey.

STATEMENT OF HON. THOMAS J. DOWNEY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. DOWNEY. I want to join in thanking you for holding these hearings and suggest to you that as a supporter of H.R. 3750, which Congressman Wirth outlined, I am particularly interested in it because of title III of the bill, which addresses the issue of planning, teacher training and software evaluation and development.

This is a bill I introduced, H.R. 1134, which is now the third title. When I first introduced legislation in 1978 to establish a system of National Centers for Personal Computers in Education, there seemed to be a clear need to provide local school districts with assistance in planning their approach to the use of computers in the classroom. There was also a need to establish a system of teacher training and information dissemination which would assist educators who were faced with the awesome task of evaluating the various hard- and soft-ware options. In the intervening years, it seems to me, the need for this legislation has increased.

In 1983, Market Data Retrieval reported that 31,000 schools began using microcomputers for educational purposes. In that year, more schools began using microcomputers than in all the previous years combined.

These numbers are impressive. But we need to ask ourselves what happens after the computers are purchased? Are they used effectively? In many cases, lamentably, the answer seems to be no. As Gregory Benson, director of the center for Learning Technologies of the New York State Department of Education pointed out in an address to the Sixth National Conference on Communications

Technology in Education and Training, "We have precious little data confirming that this infusion of technology for learning purposes is in fact making significant contributions in the cognitive and affective learning arenas."

Why is that? Partly because information is hard to come by due to the speed with which computers have entered the Nation's educational institutions. But the lack of data confirming positive results from the use of computers is also reflective of the fact that the results themselves have been mixed. Too often computers have been purchased without planning, without taking account of the special needs of the school, without providing teacher training options and without prior evaluation of what courseware will work with individual microcomputers.

We have all heard the familiar horror stories. School districts have bought computers which then sit unused because of the lack of adequate training for teachers or lack of appropriate software. Mr. Benson says that he gets calls all the time from school administrators who have bought microcomputers for a good price, but then find out that they cannot find the right type of software. Many administrators feel pressured by parents to equip their schools with the latest in computers and they do it without planning.

There are few places to which an administrator can turn for advice. Mr. Benson made a telling point in his address: "Clearly, effective administrators do not go out and hire teachers because they are bargain priced and then attempt to integrate those teachers to suit the needs of the student population. Yet, we are witnessing some purchases of instructional capacity that then requires significant retrofitting to student needs which is cumbersome at best."

While it is true that many computer companies will provide some training for teachers, generally this training deals with the use of the computer itself and does not treat the larger issues of the use of the computer in teaching, nor does it deal with the problem of evaluation of software.

This leads us to another problem which is presently coming to our attention. It seems that many schools are simply teaching computer skills; in other words, the computer itself is becoming the end rather than the means. I believe this is partly because many teachers have not yet learned how to teach with computers. What they have learned, in a brief time, is how to teach others how to use a computer. What they have not yet learned—because events have moved so quickly and because there has been little institutional support at the local level—is how to integrate the computer into their teaching methodology.

Ideally, there is no reason why computers cannot be used to assist the teacher in improving a student's basic reading and reasoning skills. In practice, few teachers have had the support they need to use computers in a broader and more challenging and ultimately more rewarding way.

I believe that the grant program to establish training and evaluation programs will help school districts and teachers by providing them with information on available systems and software, and by providing an environment for teacher training. Let me briefly recapitulate what section 302 of title III does.

It establishes a grant program under the National Science Foundation to assist various types of institutions to identify existing educational computer programs and develop new educational software; to develop teacher training materials; and to monitor and disseminate information on new materials in educational technology. I would like to make it clear at this point that the evaluation function of the computer center is concerned only with the technical and methodological questions. Evaluation of courseware is not construed as evaluating the course content of the program.

One function of the program is worth highlighting. Institutions which receive grants are encouraged to set up a mechanism to inform the computer industry of the specific needs of educators. The National Science Board Commission on Precollege Education in Mathematics, Science and Technology noted in its report, "Educating Americans for the 21st Century," that there is a great gap between teachers and the producers of computers. We must keep in mind that the development of new computer programs is a two-way street. If industry is able to ascertain the particular problems and needs of education, it will better respond to those needs.

Mr. Chairman, establishment of the National Science Foundation grant program would be a first step in dealing with the much larger issue of computers' effect on education. We must make a strong commitment to support the best use of computers in our classrooms that is possible. I believe that H.R. 3750 provides the comprehensive approach to the problems of the integration of computers into the schools that the Nation needs.

I would like to commend the members of this subcommittee for their interest in this issue and for their attention to the needs of educators and students. I am sure that together we can fashion a bill that will bring the fruits of computer technology to all schools and students in the United States.

Finally, Mr. Chairman, I would like to have the text of Mr. Gregory Benson's address to the communications technology conference included in the record of these hearings.

Mr. **Walgren**. Without objection.

[The information follows:]

Keynote Address: Education and Technology - Where Are We Going? by Greg Benson

Presented Wednesday, February 22, 1984 to the
6th National Conference on
Communications Technology in Education and Training

It is indeed an honor and a pleasure to have been invited to make this presentation at this, your 6th National Conference. I am particularly pleased and encouraged by the turnout here today and the fact that the co-sponsorship of this conference represents the kinds of inter-educational agency cooperation that must take place as we forge ahead toward enhancing learning through the use of techonologies. A review of the agenda clearly promises that for the next two and one half days we shall all be the benefactors of extremely constructive and informative presentations designed to aid us in our endeavors.

The next two and a half days will provide the forum for raising a number of critical issues related to the implementation of technologies in education. There issues relate to policy, planning, management, and instructional strategies. The discussions also hold implications for organizational change and perhaps the reconstitution of what we believe to be the basic learning theory and the capacity and rate at which individuals, children and adults, learn. I will not be surprised if the discussions of these vital issues also leads us to confront the redefinition of education and where it takes place and what the roles of the various current educational institutions will be and also what the roles of some new and emerging nontraditional learning institutions will ultimately be. This morning I will discuss some of these critical issues by addressing three major areas. First, I would like to discuss some of the general conditions extant in our society and our educational communities that define the context within which we pursue the meaningful application of technologies to the learning environments. Second, I will identify some of the common concerns raised by those who seek to promote the meaningful application of technologies in education, and third, in relation to some of those concerns, I will discuss where I believe we are headed, what some of our options for actions are, and speculate as to whether our current activities are aggravating current problems, creating new ones, or evolving as solutions to many of our chronic educational deficiencies.

First, let us look at some of the broad phenomemon affecting our society in general and our educational institutions more specifically as they relate to our overall mission in education, and more specifically to that which brings us here today.

BEST COPY AVAILABLE

I need not elaborate on the events and the array of studies and other scholarly works that have in recent times placed education under close scrutiny and in the forefront of national concerns. Reports such as "A Nation at Risk," "Action for Excellence," "Making the Grade," and John Goodlad's book A Place Called School, all bring attention to a series of difficult problems in education and offer both diagnosis and treatment related to those problems. Aside from our pride and the fact that we are in the limelight, we owe it to all learners to act in relation to many of the difficult problems articulated in those and other reports. Beyond our learners, we owe a sincere effort toward the achievement of a more creative, efficient, and productive society within which quality educational opportunities for all learners is a vital prerequisite to economic growth and quality of life.

Having established that we in education are being increasingly pressured to perform far better than we have, let me turn briefly to the technological phenomenon and its infusion into our society. The microcomputer has spearheaded a massive capital expenditure on the part of consumers in all market sectors not the least of which is education. Recently, U.S. News and World Report estimated the microcomputer market in 1982 to be six billion dollars. That market was projected to grow in 1987 to 28 billion dollars and recent Talmis data indicates that that 1987 market projection is more in the neighborhood of a 40 billion dollar market. On the courseware side, the Office of Technology Assessment Report indicated that in 1980 the courseware marketplace was approximately 6.5 million dollars and is projected to grow by 1990 to 600 million dollars. Turning specifically to the home market, in 1979 it was reported that there were seven thousand microcomputer units in the home but that by 1983 there were some 20 million microcomputer units in the home. The most recent Talmis Study indicated that by 1988 that figure would rise to 55 to 60 million microcomputer units located in the homes across the United States.

Knowing the extent of the capital marketplace and the number of units sold is but one indication of the current computer revolution. Of particular interest to educators, a recent Gallop poll indicated that two of the three most frequently cited uses of the microcomputer in the homes were "a child's learning tool", and "an adult learning tool". That phenomenon of using microcomputers in the home for learning purposes is underscored again by the recent Talmis study which illustrated that 79% of the current owners of home microcomputers indicated that the primary use of that computing capacity was to "help children develop/improve skills learned in school". Also interesting was data that Talmis collected indicating that 77% of those planning to buy micrcomputers for the home cited that same reason for considering purchase.

Turning from the home environment, where quite obviously these technologies are being applied for educational purposes, Market Data Retrieval in the fall of 1983 released data specific to the educational community which included some revealing statistics. Among those statistics, they reported that 31 thousand schools began using computers for instruction during the 82-83 school year. That represents more schools initiating the use of microcomputers that year than all of the previous years combined. The MDR data also indicated that the number of elementary schools using microcomputers tripled during the 82-83 school year and further that 68% of all schools now use microcomputers within their instructional program. Their data indicated that there are 325 thousand units located in our schools and that 86% of the senior high schools, 81% of the junior high schools, and 62% of the elementary schools use microcomputers for instructional purposes. To provide you with an indication as to what those numbers mean in terms of a school organization, the average number of microcomputers in high schools is eleven, junior high — seven, and elementary schools — three.

Further evidence of this explosive growth of microcomputers in the schools is provided by Electronic Learning's 1983 Survey which illustrated that the growth of microcomputers being applied in the instructional setting is proceeding at an astonishing rate. For instance, in Alaska between 1981 and 1983 there has been a 380% increase, in Colorado 460% increase, in Connecticut 4900% increase and in Florida a 220% increase. All of this data is somewhat dated with the exception of the Talmis survey and therefore very likely somewhat of an understatement of the massive infusion of technology taking place in our school settings.

Though I have not seen data reflecting surveys in the post-secondary area, I would project that a similar phenomena is taking place in that sector. A growing use of telecommunications for course offerings, the purchase of microcomputers by entering freshmen as part of college and university programs, the creation of laboratories for individual and group work, and the purchase of microcomputers for specific administrative and research purposes is surely contributing to a similar massive infusion of the technologies at the post-secondary level. Another interesting phenomena is the infusion of these technologies and their use for educational purposes observable in the public library community. A recent survey conducted in New York State indicates that dozens of public libraries are purchasing microcomputers, loaning them to their patrons along with software, primarily learning software, and also offering courses in basic machine literacy as well as in programming and the use of other applications software for a variety of purposes. Obviously this phenomena is not unique to New York State. The Scottsdale, Arizona library has a program of computer literacy and basic skills instruction using computers for students as young as three years old. The Pikes Peak Library in Colorado provides online access to their catalog of holdings for home microcomputer users. In Portsmouth, New Hampshire there is a microcomputer loan program and weekend workshops for twelve year olds that focuses on computer operations and basic programming skills. And of particular note, in Farmingdale, Connecticut the public library has incorporated the construction of an earth satellite station as part of their current building plans. According to the recent report published by the National Commission on Library Information Sciences the reasons libraries cite for entering into the use of these new technologies include the distribution of instructional video and courses of study, the provision of teleconferencing for continuing education purposes, and the downloading of courseware for multiple applications to learning in other settings.

All of this data has a distinct and undeniable message. Technologies are being applied for learning purposes across all of our educational and cultural institutions. These institutions are awakening to a new role and contribution that each can make to the improvement of our educational endeavor in this country. The technologies being applied are not restricted to the microcomputer as is evidenced by some of the applications cited earlier. Also, it is common to see the application of the videodisc, online information services, and sophisticated telecommunications capacities to support the development of these new educational roles being played by these institutions. The "treatment time" related to the application of these technologies in learning environments is scant and therefore we have precious little data confirming that this infusion of technology for learning purposes is in fact making significant contributions in the cognitive and affective learning arenas. What is observable at this point in time is discouraging in some respects and relates to the inequitable distribution of this new learning capacity across our educational and cultural institutions and their populations. Again, Market Data Retrieval illustrates this point. Their data indicates that the more wealthy districts, as measured by those districts having 5% or less of the families at the poverty level, in 1981, 29% of those wealthy districts used microcomputers for instructional purposes, in 1982 that figure grew to 44%. Contrary to that growth, the poorer districts, measured as those having 25% or more families at the poverty level, in 1981, only 12% of these districts were buying microcomputers for instructional purposes, and in 1982 that figure grew to only 18%. This data would indicate that in the elementary and secondary schools we are observing a growing disparity related to the introduction and use of microcomputers for instructional purposes that is based on school district wealth. To reinforce that data, Market Data

Retrieval also found that 80% of the 2,000 most wealthy school districts used microcomputers for instructional purposes while only 40% of the two thousand poorer school districts in this country used microcomputers for instructional purposes. These characteristics of the wealthy districts would also seem to be related to their ability to pay for and designate resources specifically for deliberate planning for the integration of microcomputers into the instructional setting and further, the provision of continuing inservice education to keep their professional staff abreast of the latest technological developments and their implications for instruction.

This inequitable distribution of this new learning capacity would seem to demand thoughtful action rather quickly. It would further seem that central to the action taken would be the provision of inservice education so as to educate our professionals to the benefits and appropriate applications of technology. The recent Electronic Learning (1983) Survey of the states indicates that only two states require inservice education of this nature. Interestingly enough, those two states represent only one percent of the K-12 student population in the United States. In relation to preservice education requirements, Electronic Learning found that only eight states require such preservice education and those states represent only 3% of the K-12 population. Clearly, our current formal response to this vast infusion of new learning capacity is lagging behind our needs to address some rather urgent problems.

Thus far we have seen the evidence of a rather incredible infusion of technology in the learning setting across our educational and cultural institutions. In addition, we are witnessing some rather unfortunate circumstances relating to the inequitable distribution of that learning capacity. Before moving to some specific concerns and issues let's briefly look at some of the barriers we in education confront that are related to our organizational makeup and behaviors. Education is a highly segmented arena. We divide education by level, by program, and by a variety of institutions that focus on specific educational problems or funding patterns. That scenario makes it difficult to effectively apply technology to transcend all of those "superficial" boundaries and further, apply those technologies so as to represent learning capacities much more attuned to mastery as opposed to level within a structure. Education has also been slow to change. Long ago studies by Guba and others indicated that it was some 30 years before a quality educational innovation was fully infused productively into our respective organizations. Contrast that timeframe with what we have been discussing in terms of the infusion of hardware in our schools but keep in mind that the existence of hardware is not necessarily related to a quality innovation. Education at this point in time is also represented by staff at or near the top of salary grades having accomplished all or nearly all of the educational requirements related to their position. In fact, we are seeing an out-migration of those teachers with skills to offer to the new high technology ventures. We in education are also very much "tradition bound" and in many respects "contract bound".

At the same time, we in education are blessed at the moment with some of the most creative minds and highly motivated individuals ever available to us to address the urgent problems we confront. We shall need to apply all of that creativity and test the outer limits of that motivation because we are being challenged and threatened by questions that seriously address themselves to the very foundation of our current operations, theories, and frequently our desires. We are being threatened by the emergence of commercial educational opportunities and that phenomena is worrisome. It is worrisome because only public education is committed to providing equality of access to educational opportunities, and though the commercial sector is driven by "equity", it is an equity of a tangible sort and not one that typically parallels our concern for equality.

Before we dismiss this phenomenon of commercial education as far fetched, observe what happened in the airlines industry, the automobile industry, the trucking industry, and those problems that recently confronted Greyhound. Many of those industry related difficulties can be traced to a tradition and "contract bound" organization that could not respond to the emerging technologies and the capacities inherent to them. Smaller, more fuel efficient airplanes capable of profitable, short and medium range trips tailored to smaller market segments quickly emerged in the airline industry and brought many of the major passenger and freight airline corporations to their fiscal knees. Though I am hopeful and optimistic we will not see such a phenomenon affecting public education we must now be aware that a scenario of that nature is very possible and could severely threaten the quality of education ultimately offered to our society of learners.

It is clear that we are already seeing signs of this "defacto deregulation" of our public educational system since a number of services typically provided by regionally centralized sources, whether in higher education, state education agencies, or intermediate service agencies, are being decentralized to local sites and addressing tailor-made applications in extremely cost effective ways. This trend will continue and we need to address in earnest what the new and emerging roles will be for these intermediate agencies that heretofore provided centralized services. We need to be prepared to effectively manage their decline as direct "systems" service providers and develop and encourage alternative support services for those institutions.

Regardless of the actions we take, I do believe we will see alternative commercial education. Further, I believe we will see within a short period of time Federal Tax incentives that will accelerate that evolution. Understand that I am not adverse to these alternatives to public education for they may in fact offer extremely high quality learning alternatives and play a vital role in the provision of opportunities not previously available. However, I am very much concerned as to the price that might be paid by public education as a result of such an evolution and the loss of opportunities to many that public education affords for both educational and cultural pursuits. We must understand the liabilities related to these trends and initiate positive actions now so as to maximize the potentials through leadership and partnerships.

The convergence of these events and resulting observations, both positive and negative, fall under the popular label of the "information society". I believe this to be a misnomer. Information unto itself does little or nothing. It is only of value when comprehended, manipulated, integrated, and in short -- learned. In our business of education we measure our productivity by the scope and rate of learning. We also measure our success and productivity based on the creative application of what has been learned and that is not substantially different than the businessman using Visicalc. In that case, data on production, pricing, inventory, distribution, and sales are mainpulated and placed in juxtaposition. Through this process, the businessman learns the essence of business successes or failures, enabling informed predictions and creative action. Applications software in education should do no less and in so doing will truly move us from the "information society" to a "learning society". To amass the resources required and address the problems inherent to reaching and achieving the potential of a learning society will represent a challenge that we have never faced. It is a challenge that must be met with some sense of urgency since the evolution to a learning society is not going unwitnessed by the commercial sector and inherent to that unchecked move are the concerns I raised a moment ago.

In order to meet this challenge what must we do?

- First and foremost I believe we must broaden our perspective beyond our programatic concerns and beyond some of our traditional views of highly structured learning to be more consistent with the current and emerging technological capacities being infused into our learning environments.

- We must also enter into creative partnerships with the commercial sector so that together we can move our society to the realization of the capacity of learning in any environment.

- We must focus those partnerships on the integration of technologies across our institutions.

- We must use our technologies to enhance learning opportunities that might not otherwise be afforded to large numbers of our less advantaged learners.

- We must fully integrate the use of the various technologies among themselves and within our curriculum areas focusing on multidisciplinary capacity whenever resources allow.

- We must review the role and make up of our organizations and assist our teachers and administrators in becoming more efficient managers of learning regardless of where the actual learning site truly is.

- We must exert strong, perhaps nontraditionally strong, leadership in order to achieve many of these objectives.

- We must aggregate our traditionally segmented market and leverage our buying power so we do not accomodate technology designed for other purposes but rather influence the design and quality of hardware, software, and telecommunications configurations so they are directly responsive to the requirements of education.

- We must prove to the commercial sector that we are far wiser and more preceptive than our most recent purchases would indicate.

- We must illustrate through our partnerships with the commercial sector that we can overcome our traditional segmented approach to learning and therefore aggregate the intrm and interastate markets thus attracting the commerical capital investment required to address our requirements as we articulate them. I honestly believe that this segmented pheomena in our market sector, for whatever good rationale by which it emerged, is a fundamental weakness undermining our ability to influence products and services in the learning setting. My own commerical experience dealing with the education sector met with a good deal of success, as measured by revenue, mainly due to that unfortunate segmented circumstance. We found, and I am sure that many other businesses have as well, find that sales by persons well versed in educational structure can sometimes be two and threefold beyond revenue projections because educational institutions do not share the capacities inherent to purchases and therefore frequently far more capacity is purchased than is ultimately required.

Having addressed some phenomena extant generally in our society, more specifically in education, and having alluded to some of the problems and some of what we must do, let's turn to some issues in some greater detail that all of us face as we attempt to effectively infuse the use of technology for educational purposes. Clearly, time does not permit that we discuss all of these nor that we seek the level of specificity required in our day to day work. Rather, I will raise some of the central concerns and illustrate where observations lead me to believe we are headed and whether our actions are aggravating existing problems or in fact offering realistic solutions.

As mentioned earlier one of the first concerns that emerges is that of equity. We have growing evidence that wealth determines whether schools and cultural institutions have the hardware to open the electronic textbooks of today. Further, that wealth can determine whether institutions provide quality and continuing inservice education for the professional staff to better enable the effective use of technologies. Wealth also determines in many cases whether institutions undertake deliberate planning based on student needs which ultimately drives software and hardware purchases. And unfortunately, wealth often determines whether increased learning opportunities are afforded to students that might not otherwise have such opportunities. We know that there is a disparity and that technology is contributing to that widening disparity and that is a problem.

In order to address this problem we must develop laws and policies that reduce this disparity and provide increased opportunities, particularly to low wealth institutions, in order that they might avail themselves of these new technologies and creative learning opportunities inherent to them. We must develop a coordinated capability to widen our purchase agreements to include discounts for students and parents and a variety of other institutions undertaking learning and educational efforts. In these ways, rather than allowing technology to aggravate what has been a persistent problem in education we can use the technology to address our equality of access problems that have plagued us for so long.

A second issue we typically confront very quickly is that which relates to the myths surrounding the use of technologies for learning purposes. Surely you have all observed the dozens of television and magazine ads indicating that if only you would purchase a microcomputer for your child he/she will be accepted at the institution of choice, be successful at that institution, and very quickly become an extremely high-paid contributing member of our society. Though that myth is somewhat superficial to those who know better, it is still proving to be an extremely effective marketing approach. Of a more practical nature there is another myth, one I call the "stand alone micro myth". This myth has several dimensions. Let me relate one of the dimensions of this myth that I encountered while working with a school district. I was asked to address the first meeting of the computer committee formed by the school district to address the problem of integrating the microcomputers as instructional tools in the K-12 arena. Through the course of our discussions we began to develop a scenario as to the "best case" as envisioned by those embarking upon this new venture. As might be predicted the stand alone micro, fully equipped with high resolution color monitor, CPU, dual disc drives, and a printer was judged to be the computing configuration to be placed on each student's desk as an ideal classroom situation. It was felt early in our discussion that 25 such fully equipped systems would provide untold learning opportunities for the students who might use them. Upon further investigation along budgetary lines it was discovered that the printer would need to be of the impact type. Now imagine for a moment 25 impact printers all responding to the "print" command simultaneously. Aside from some other inherent problems with this particular design, the level of noise would surely exceed OSHA standards.

Another dimension of this "micro myth" relates to the contribution this classroom configuration really makes to the effectiveness of teachers and administrators as learning managers. Picture the teacher at the end of the period with 25 dics, at the end of the day with 125 discs, and at the end of the year with several thousand discs. The disc management problem alone leads one to question this "mythical solution" to our educational problems. Let us look further. At the end of the period or the day, how does a teacher determine the performance of a student on a given program? She cannot hold those discs up to the light. Rather, she will need a machine to read those electronic worksheets and unless she owns the same machine at home she will be spending untold increased hours in the school building determining the performance of 25-125 students per day as captured by those disks that we assume have not been folded, spindled, or otherwise mutilated or damaged by spilled milk or orange juice. And what does that teacher do once she has deciphered what the performance was of each of those students? You guessed it, she enters that performance into the navy blue grade book that we in education have been using for 200 years. She has no way of looking across her classroom in a "realtime" situation to determine who is and who is not proceeding with the mastery of the learning objective inherent to the courseware. This configuration of technology for learning as a classroom system has in fact made our teachers and administrators far less efficient. To the extent that we are so doing, we are spending dollars on hardware and software and decreasing our productivity and return on our educational resource committments. The extension of that "model" we are seeing in schools today is a sewere problem. In order to address that phenomenon we must look at and influence the development of systems that provide for realtime monitoring, not only of those students in the classroom at the time, but of students in homes, and adults that may desire, for upward mobility purposes, to take a course in mathematics at 10 a.m. and if unavailable at 10 a.m., to take that course in the evening and have their performance data available for teachers the next morning. We need to influence the development of high quality student diagnostic data and the online capacity for test item generation and item analysis so as to eleminate non-descriminatory test items automatically. We must influence the design of administrative reporting procedures that draw upon the instructional setting and the performance therein to inform administrators as to the realtime progress and achievement being made by learners entrusted to his supervision. We must address these capabilities as a school "education utility" notion and in so doing only then will technology be used to increase teacher's effectiveness as learning managers. Only then will our technology be affording solutions to some of the learning and management problems being pointed out to us.

Let us turn to another issue central to our concern, that being related to the availability of quality software. Unfortunately, the preponderance of courseware is designed for the stand alone micro which as a system of instruction I believe is somewhat bankrupt. Further, that software is predominantly drill and practice though we are beginning to see far more sophisticated software being used in the schools. The predominance of drill and practice is obviously related to the required commercial capital outlay for software development and specifically, that the least investment is required for drill and practice software.

Let's look further and somewhat more closely at some of the characteristics of the software. For some strange reason there is a large number of courseware packages on the market that do not allow you to "turn back a page". I am not sure what the reason is, but apparently electronic pages, once turned, stick to each other. It is obviously somewhat restrictive in a learning environment and impedes a students natural tendency to review and clarify. A large share of the courseware currently being used today also lacks good diagnostic capacity related to the learner performance on instructional objectives inherent to the courseware. This deficiency provides little or no advantage to the teacher and in fact renders the teacher less efficient in many respects. Much of the courseware we see being used in the schools today also flies in the face of good reinforcement theory. How many times have you witnessed a student being repetitively reinforced by statements such as "Wrong, Try again, Hit Return". Much of the software also lacks good documentation that informs a teacher as to the operation of the program, the best context for its use, and suggests effective ways for integrating it into the curriculum. Much of the courseware also lacks effective "help functions". I have sometimes found myself "trapped" in menus that were supposedly designed to help me. Much of the software in use today also has extremely narrow parameters for accepting correct responses. For instance, in a georgraphy lesson the appropriate response in full might be "D. Potamic River". A student, when asked to provide that response might enter "D" or "D Potomic River" or simply "Potomic River". Some of the programs in use today would accept none of those responses when the student had learned that the correct response is the "Potomic River". The student's problem obviously was with the instructions for entering the appropriate response. However, since with many programs the student cannot page backward to review the instructions, this narrowness of response acceptance can cause some significant problems and result in application of negative reinforcement, perhaps ad infinitum, which unduly disrupts the student's learning progress. Judging from your response, I am sure you have all encountered one or more of these obvious deficiencies in software. Basically, it illustrates the lack of a sound pedagogical base and an insensitivity to the human behavior and learning patterns and in that regard it represents a significant problem. This problem manifests itself through but the superficial application of computing power inherent to most of the computers being used in the schools. It also illustrates little or no attention to good educational theory. To address these deficiencies we must influence the products. We must work in partnerships with commercial producers of software and clearly define our pedagogical requirements through the aggregation of our markets to guarantee true developmental responsiveness on the part of those commerical producers inclined to listen.

Also related to software, I think we must stop the exhorbitant expense being incurred by many local districts who are evaluating software already on the marketplace. At that point in time it is far too late to influence the product. If the product is selling, and the inventories are high, the commercial producer certainly will not modify that product. Through an informal survey in New York State, we discovered that there were dozens of local and higher educational institutions involved in courseware evaluation. Rather than add resources to that already seemingly overdone process, we made the decision to apply our resources to the coordination of information emanating from those evaluation efforts with the hopes that we might ultimately influence some agreement as to the criteria being used for evaluation and standardize the expression of the evaluation outcomes. Our objective in that regard is to determine the extent of duplication of efforts and perhaps influence a reduction of resources being spent in that area and also make the evaluation results available in print and electronic form. I believe our resources are far better spent in attempting to influence new products while in the development stage.

I had the opportunity to test this public/private shared development notion during a presentation at the Talmis conference last week in Chicago attended by representatives of nearly every major commercial producer of instructional software. Those represented were most interested in such partnerships at the developmental level. The responsibility now rests with us to effectively represent our educational marketplace in such partnerships. Only through mechanisms of this type will we see instructional software being designed in accordance with our pedagogical, content, scope, sequence, and concerns and sensitivities for cognitive and effective behaviors of the learners.

One other avenue I might suggest as potentially fruitful in this area of quality software relates to efforts to transfer educational and training designs from the military sector to the educational setting. A number of efforts are underway by a variety of states and The Council of Chief State School Officers is pursuing a more formal relationship for development of such a military technology transfer program.

Another issue that arises as a central concern is that of the provision of high quality and continuing inservice education for our professional staff. Unfortunately the popular view of inservice education has been machine-focused. We all have appliances far more complicated than a microcomputer and somehow we have learned to use our toasters and dishwashers without a course in "dishwashing literacy". In fact we can readily overdo this machine focus of computer literacy and in so doing can cause some significant difficulties.

Picture one such case where a local teacher attended a computer literacy program focused on the hardware and quite clearly learned that the appropriate configuration for her classroom included, as I mentioned previously, the high resolution screen, CPU, dual disc drive, printer and modem. The resultant purchase order included twenty five such configurations including the modems since it was the desire of this teacher to place upon the desk of every student access to the "world of electronic publishing". Now I believe there are several difficulties inherent to that particular configuration not the least of which is the fact that there were no phone lines in that room and therefore the modems were rendered useless. That kind of focus on the machine also tends to spawn the use of computers and other technologies as separate courses of study rather than as integrated tools of instruction. The logical extension of that can be a significant problem. Treating the vast computing resource as simply another subject does not do justice to or recognize the capability of the technology nor does it increase productivity of teachers and our administrators. Our inservice education programs must include orientation to all technologies and their appropriate uses for instructional purposes. Inservice must include the ethics involved surrounding the use of computers and the societal impact, both positive and negative, related to our emerging computer society. Inservice education must be on a continuing basis and address new high quality application programs and how they are best integrated into the curriculum and content areas. Our inservice programs should also include administrators to insure that computing is addressed within the context of a deliberate planning effort that focuses on student needs as the driving force rather than which piece of microcomputer hardware happens to be on sale that week. Clearly, effective administrators do not go out and hire teachers because they are bargain priced and then attempt to integrate those teachers to suit the needs of the student population. Yet, we are witnessing some purchases of instructional capacity that then require significant retrofitting to student needs which is cumbersome at best. Through inservice we need to introduce our teachers to the vast array of databases which students might use for learning purposes. These kinds of content areas must also be included in preservice and in so doing we must realize that this preservice/inservice effort will be extremely intensive and require extensive amounts of resources. Only through this extensive and intensive effort will our educational professionals be equipped to truly apply technology in creative more productive ways for learning purposes.

The last issue has to do with telecommunications. Addressing this issue requires, more than any other, a broadening of our perspective. We as educators must think beyond the edge of our desks, the confines of our office walls, the parameters of our programs, and the boundaries of our states. We must broaden our perspective because telecommunications epitomizes technological transcendence beyond those superficial limitations. In that regard I congratulate states like California that has proposed a multifunctional telecommunications network development effort to address that state's economic and educational concerns along with the conduct of a variety of other states services. Also to be congratulated is Massachusetts that has created the Massachusetts Corporation for Educational Technology that has laid out a first year plan for addressing the telecommunications needs specific to the educational community. In my opinion I prefer the California model in that it aggregates state functions and focuses on economic development which I suspect is more politically viable and more likely to achieve recognizable results in the short term. At the same time, any significant telecommunications capacity developed for broader purposes can meet all or some of its educational needs.

In retrospect I marvel at the foresight of New York State when it created the State Thruway Authority which transcends traditional program and state agency lines and ultimately built a highway system that provides the assurance to every homeowner that he can build his highway onto the street and that the street will connect to a town highway and further to a county highway and interstate highway which shares traffic and costs across as wide a consumer base as is possible on a usage basis. I have suggested that in our state the Education Department urge the Governor's Executive Staff to pursue a similar avenue regarding telecommunications. In the meantime, we need to pursue efforts such as those being pursued in Massachusetts that take stock of our telecommunications capacity resident in education and begins to articulate the telecommunications system requirements we view as critical for our business of learning.

Another major telecommunication concern rests with what configuration of communications is required at the district or community level. We need to begin thinking about and developing requirements for what is typically being called the school or "educational utility" at the local setting. Such a utility must provide for access by all of our educational and cultural institutions and must provide access for homebound learners and those adults desiring to take advantage of our learning opportunities from their homes. We can continue what is generally a lack of coordination and development in this critical telecommunications area and therefore duplicate resources for planning and implementation which will reduce the general funds available to use and therefore reduce the proportion of funds we can use in education. I need not tell you that any reduction of resources available to education is a significant problem. On the other hand, we can puruse the avenues provided through enlightened and broadened perspectives such as is being pursued in states such as California and Massachusetts. In so doing we can decrease the educational resources required for the ultimate development and maintenance of effective telecommunications capacities on an international scale.

I have touched upon what I believe to be some of the critical issues confronting those who take seriously the enhancement of learning opportunities through the use of technologies. Our progress is frought with barriers of all kinds, but yet neither you nor I would be here today unless we shared a vision. A vision that we can influence the design of systems at the desks of all learners that allow for the integration of software and good classroom management information and administrative data. Systems that allow for instructional pursuit whereby a student upon entering the system to study history discovers that Napoleon's defeat was determined in large part by the climate and then shifts from history to climatology which leads to an exploration of the formation of our oceans and seas and thus provides for the most exciting individual student intellectual journies that we could ever imagine. I think we also share a vision of systems and educational process where we reward students for the most creative questions rather than the recitation of the most appropriate response. I believe we share a vision where teachers and administrators truly become effective learning managers and guide the individual student journies while having more time to work with those students who need special attention for either remediation or enrichment purposes.

Given the myriad of problems relating to both individuals and organizations we must encourage and ourselves be thoughtful risktakers willing to make and mold tomorrow's opportunities for improved learning for all children and adults if we are to realize that vision. There are technology pioneers and heroes. They are electronic engineers or software engineers that forge new electronic circuits, make them in miniature and provide for us untold technological capacity. We need to create and encourage pioneers in the area of educational applications to pursue and achieve our vision for providing students with exciting intellectual learning opportunities that the technological capacity currently allows and will surely provide in greater measure in the very near future.

As I was leaving yesterday afternoon to come to this conference, I was walking out the door and my wife said to me, "Don't forget, times have changed." Having spent most of my life dealing with and having to accommodate extremely rapid technological changes, I was rather intrigued as to why she would warn me "Times have changed." In order to determine precisely what she meant I stuck my head back into the door and asked, "What do you mean. Times have changed?" She said, "Well in Biblical times it would have been a miracle if an ass could speak. However, today very frequently it is a miracle if an ass can keep quiet." Taking careful heed of that admonition that preceeded my trip to this conference, let me close and wish you an extremely profitable and informative two and a half day session here in Washington. Thank you very much.

Mr. **Walgren**. Thank you very much for your introduction to what is a weighty subject. I would like to ask impressions in general about the degree of distribution that we could anticipate. One thought is that computers are so expensive that a small number of units will burn up all available funds that could possibly be directed in the acquisition area.

Tim, you mentioned $4 million being at least—not a threshold, but a covering number. How broadly would you anticipate being able to reach with this kind of legislation?

Mr. **Wirth**. The initial legislation—if I might, Mr. Chairman, the initial legislation that we had discussed with the Committee on Education and Labor called for a 10-year program of approximately $300 million a year and that would be adequate to make sure at the end of that period of time phasing up from the poorest schools to the more affluent schools—those most in need, to those least in need—that that would then be adequate to assure that not only was there hardware available in all of those schools for the known needs of the schools, but also the kind of teacher training that Mr. Downey was talking about and the kind of software evaluation that Mr. Gore's bill goes to.

Mr. **Walgren**. Do others have any comments they would like to add on the reach of the legislation? Are you concerned that it won't reach?

Mr. **Gore**. Concerned that it won't reach——

Mr. **Walgren**. Well, that it will put one computer in one school in Memphis and that will be all?

Mr. **Gore**. Well, I think your question probably is more on point with the legislation of Mr. Wirth and Mr. Downey. In the case of the software legislation, or H.R. 4628, it has a modest reach, but it hopefully would stimulate the development of a sizable quantity of high-quality educational software. It is not intended to favor any format at all. It is intended to encourage greater ease of transition—of translation—between different formats.

You know—and that is one of the real problems, Mr. Chairman. One of the witnesses in these hearings last fall outlined the problem by comparing it to phonograph records. He said if you had a marketplace for phonograph records, that was divided not only into 33⅓ RPM records, 45's and 78's, but also 100 other RPM categories, and no single category had more than 10 percent of the market, then you would have a situation that is roughly analogous to what you have had with educational computers today, not 100 different, but quite a few different formats. And a talented software writer can invest an enormous amount of time and money and have great difficulty reaching more than a tiny fraction of the market because it is so fragmented.

Some of the larger companies go to some lengths to lock in their good products into their own format, that is to design the architecture of the program in a way that makes it almost impossible to translate into other formats. So that is the problem that this bill is attempting to solve.

Mr. **Downey**. I am reminded—we make military comparisons all the time. If we are going to be candid, the only problem that this faces is whether or not the Congress is going to be prepared to spend the $300 million over the next few years to provide the computers. While certainly we want you to do that, I think it is important to make a couple of the comparisons that are often made with military programs. People flying the airplanes in the future have to be trained, they are going to be trained in computers. The cost of the B-1 bomber, for instance, the unit program cost of the plane, is $400 million, one of them, and we are going to build 100 of them. This program will cost 75 percent the cost of one airplane.

Mr. **Walgren.** Well, I want to yield to my colleagues, with thoughts they may want to raise.

Mr. Mineta.

Mr. **Mineta.** Thank you, Mr. Chairman.

Mr. Wirth, you touched on this very briefly, but there are other bills before the Congress which provide tax incentives to corporations who donate computers to schools. On the other hand, your bill utilizes a direct grant approach to—in contrast to the tax credit approach. I am wondering why your bill uses this approach. Why should we allow or why should we have a bureaucracy, I guess you might say, administering this in a sense rather than letting the Tax Code sort of determine what that marketplace influence might be?

Mr. **Wirth.** I am not a member of the Committee on Ways and Means, I defer some of that to my colleague on the right, but let's remember that there is no difference between a tax expenditure and a direct expenditure. They are both allocations of taxpayer dollars. That is issue No. 1.

Second, the inequities built into the kind of legislation that may come before us in the so-called Apple bill does not address the rich/poor or the geographical distribution issue.

Third, the so-called Apple bill does not even touch the question of teacher training, software evaluation, modeling, and so on that are so essential, and we learned those lessons again, as I was suggesting in my testimony, very bitterly, I think, in the sixties with the Title I Program in which we hurled at school systems a great deal of hardware, but they didn't know how to use it. We hadn't phased it in. Let's learn those lessons which are not reflected in the Title I Program.

So those three reasons, it seems to me, argue very strongly that this kind of an approach rather than the tax credit approach, which is a very blunt and I think in this instance a very wasteful way, potentially, of going about accomplishing a noble purpose.

Mr. **Mineta.** The bill allocates money to a State only if that State has an application on file with the Department of Education, is that correct?

Mr. **Wirth.** That is correct.

Mr. **Mineta.** Now, why was this approach taken rather than a grant formula which might favor the States with the greatest need?

Mr. **Wirth.** I think there is also, you will find in the legislation, the emphasis and priority placed on school districts with the greatest need and that comes through the application that is made by that particular State. We have two ways that we can go about doing this, and we have been struggling with this for 20 years. One is to have individual school districts apply directly to the Department of Education, and we have been through a lot of that, I don't think with great success. What we did in the late sixties and early seventies was to strengthen State departments of education, and I think we did that successfully, and using the criteria laid out in the legislation to allow the State departments of education to be the fundamental conduit, which I think is also consistent with the constitutional mandate that education is fundamentally left to the States. So there is a balance here.

Your question goes to a difficult balance, a difficult question we have been looking at for 20 years. We tried to address that by using predominantly State departments of education and State applications.

Mr. **Downey**. Can I address the question of the tax credit for a second?

Mr. **Mineta**. Surely.

Mr. **Downey**. That is Mr. Stark's bill, if I am not mistaken. We have found when we do tax credit legislation on the Ways and Means Committee, that it is just a different type of expenditure, and it is much less targeted and much less focused. For instance, the targeted jobs credit which we currently have and of which I am a supporter, is a wonderful thing for people to receive. The fact is that a lot of people receive it who don't really need it, and we have never found a way to try and just target it to the people that need it. We have made all sorts of attempts. So I would prefer to do directly rather than indirectly what Mr. Wirth's bill does. It does provide us the ability to provide scope and focus that, frankly, Pete's bill doesn't. I don't know where Mr. Stark's bill is in the committee, but he, as I understand it, is interested in appending it as part of the current conference, but I doubt that he is going to have much success in that effort.

Mr. **Mineta**. That bill did pass the House in the 97th Congress, as I recall, quite easily, and it was inaction on the part of the Senate that killed the bill.

Mr. **Downey**. I don't see it moving in the Senate this year either, to be honest with you.

Mr. **Mineta**. With regard to this issue of allocating moneys to the States, is there any provision in the bill for disseminating information about the program to the States in your H.R. 3750?

Mr. **Wirth**. Yes. The answer is yes. What we have done, as Mr. Downey pointed out, he had a piece of legislation which he has had in for a long period of time which we merged with H.R. 3750, put them together, both of which are designed to provide and get out information about what works and what doesn't work. There is no point in going around the barn and reinventing the wheel; and what we have done in title III is focus within the National Institute of Education the capacity for evaluation and dissemination. That then gets over to the edge of what I was suggesting earlier where we may have complaints from some publishers or software manufacturers and so on that the government is getting into their business. Therefore, what we have done is any kind of this evaluation is done on contract, so it is contracted out to the private sector and you don't get the government into the publishing business.

Mr. **Mineta**. Let me ask about the hardware piece of it. You are addressing right now the software and the teacher training part of it. What about the hardware? In terms of this program, is there any provision in the bill providing for dissemination of information to the States, availability of this money for being a part of this program?

Mr. WIRTH. It is—we do not get into the evaluation of hardware. It is software and how a system uses the material, how a system uses and integrates into its curriculum the computer and the software that is the primary emphasis of title III.

Mr. MINETA. In Mr. Downey's original bill, it was to be under the Department of Education, but in this bill it has been incorporated now to be administered by the NSF. There are two questions I would like to ask about that. One is why was this change made, and, second, the NSF says that they have ample authority and resources to achieve the goals of H.R. 3750 under existing programs.

So, do you agree with their evaluation?

And the second question is on whether or not NSF has the adequate resources. But, first of all, why was the change made from the Department of Education to NSF?

Mr. WIRTH. We have a cooperative arrangement between the National Institute of Education and the National Science Foundation in the legislation and it was felt that this was predominantly a scientific program, and we did not want to get into a lot of the sort of the backwater arguments related to Federal support of education through education and so on. That raises all kinds of issues as you are familiar, Mr. Mineta.

The second issue, the NSF or the administration saying that they have plenty of funding to do everything that we wanted to, that is just balderdash. If, in fact, we have that kind of funding, why aren't we reinstrumenting Federal laboratories? Why aren't we doing a job with junior faculty and universities to maintain them there? Why are we seeing the facilities of junior universities falling apart? Why are research and development drying up all over the country?

It is ridiculous for the administration to argue that the amount of funding going into research and development is adequate when it is declining in this country when other countries, particularly the Germans and Japanese, are on the upswing in terms of research and development.

The sooner we put the correct lens on that nonsense, the better off the whole country will be.

Mr. DOWNEY. This administration says nobody is hungry in the country, either, and that it is shown by statistics and studies by all over the country to be incorrect. It is similarly incorrect to suggest that the money or the effort had been made in either the NSF or in education to do any of the work that we contemplate doing in these bills.

Mr. WIRTH. It may well be, Mr. Mineta, that members of this administration can very well buy a lunch on Rodeo Drive or buy a computer there. But there are not a great majority of the people in this country who frequent those environs.

Mr. MINETA. Thank you very, very much for your work in developing these two bills.

Mr. WALGREN. Thank you, Mr. Mineta.

The Chair recognizes Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

I don't have any questions. In my mind the bills are addressing a matter that ought to be of concern to all of us. Our educational systems are clearly going to have to be a part of the information age and the age of computers.

As the means in which that information is processed, disseminated and certainly the learning process is involved, I am sure is a tremendous challenge to American education, which already had plenty of challenges unmet before computers came along.

Frankly—and this is more of a comment than it is a question of the witnesses—Mr. Chairman, there is much in the reports, the material that is here, that is a matter of first impression. I have some concerns as to what is the appropriate Federal role in this, given the measure of Federal capabilities.

I have some concerns about grants for computer hardware and software as opposed to block grants, where some school systems need more of this and others need more of that.

I have some concerns as to whether or not by block grants, if this is a priority need of a given school division, it gets a chance to do it with the minimum amount of Federal involvement and bureacracies and the slippage of funds that go into the program as opposed to administration.

I don't know that we advance the inquiry a lot in terms of what this committee needs to learn about these bills, in terms of rearguing B-1 bombers and how much defense we do or don't need relative to the immediate needs and the relative needs of education.

I am struck by some of the figures in the report that comes to us from the Education and Labor Committee about the remarkable enhancement in the number of microcomputers available in the American secondary school systems.

Something like going from 81,000 in the fall of 1980 to 325,000; that is a tremendous incremental leap.

I, therefore, am going to be interested in looking at these bills in terms of how much emphasis is there on the accumulation of hardware versus the accumulation of software, the training of teachers in the educational techniques that relate to computers.

We have much to learn in this committee, and, frankly, I am at a very beginning point of the learning process. I thank the gentleman for the fact that they are going to make me learn some things that I really have to find out a great deal more about.

Mr. Wirth. Mr. Chairman, I would just like quickly—the points Congressman Bateman raises are ones we have been struggling with for a long time. What is the role of the Federal Government in this kind of aid?

We went through that in vigorous debate, discussion, some disappointments, some successes in the 1960's. The question of block grants versus targeted programs, another issue.

Both of those are going to be around. You and I, if we are here for the next 10 or 20 years, will have this same debate at this point. And what we have done in this bill is to try to recognize those two problems and say, OK, what is the national need and what is not?

The third issue you raised, which is absolutely valid, which Mr. Downey touched on a bit with reference to the B-1, is, what priorities do we have in this country? There are some places we will agree and won't agree on what comes first.

We just happen to agree their investments in our own backyard reflects at least my own commitment that education is our best defense and we want to start there.

Finally, on the training of teachers, one of the programs which we did very successfully in the 1960's was the training and retraining of teachers. One of the things that we learned how to do better than we had ever done it before, through a variety of programs that we experimented with in the 1960's—we now have developed a cadre of institutions around the country, a group of institutions around the country, where through the kind of summer training programs managed in our legislation, we would be able to again reinstill a sense of excellence, a sense of commitment to this program among a lot of teachers who are currently perhaps teaching social studies or home economics or English or whatever, who could quickly be converted into teachers to work on this.

We do not imagine, Mr. Bateman, nor I think do you, that suddenly we are going to be able to recruit into the school system a vast number of computer technicians, or a vast number of math and science college graduates. It is not going to happen. Realistically, what we are going to have to do is retrain a lot of teachers. That is a major emphasis in the bill.

I think that was the final point you made, which is absolutely accurate.

Mr. **Bateman**. I think we hopefully would all find immediate agreement that great, sophisticated hardware and equipment in the hands of people who don't know how to use it effectively and train people is a waste of money.

Mr. **Downey**. Mr. Chairman, if I could address some of Mr. Bateman's concerns. Let me just put in a word for Congressman Gore's bill for a moment, based on personal experience.

Several weeks ago I spent a Monday up in Boston traveling to venture capital firms. The first one I went to was a place called Spinnaker, which makes educational software for home use, basically games for kids to play, in which they can learn motor skills, eye/hand coordination, spelling—a whole host of things.

I asked at the time, that was terrific, but what was being done for the schools? And they both looked at me in a kind of blank way and said nobody wants to get into that because of the problems Mr. Gore outlined.

I think as far as we can go, with respect to dealing with software, there are some very real limits, as my colleague mentioned. And it seems to me his bill really addresses, I think, in a free market context, an attempt to deal with that problem, which we need to deal with.

My bill attempts, and Mr. Wirth's bill attempts, to deal with the question of, once you have it, how do you explain it to people and how do you give it to them? There is nobody here that would suggest for 1 minute that Great Neck High School on Long Island, or in Silicon Valley, or even in your district, that the smart districts with money are going to have all this stuff and know how to use it, and they are going to get a big headstart.

And the challenge that we face in a democracy is making sure that not only do we encourage greatness and excellence, but that we allow everyone the same opportunity for greatness and excellence. That is another consideration that our bill addresses.

Mr. **Walgren**. Thank you, Mr. Bateman.

Mr. Valentine.

Mr. **Valentine**. Briefly, Mr. Chairman.

Mr. Gore, your bill creates a venture capital corporation at the Federal level. What Federal agency or organization do you expect would have the responsibility to administer or supervise this corporation?

Mr. **Gore**. It is intended in the legislation to be an independent joint public/private corporation. I would certainly have an open mind on any suggestion by this subcommittee that it be placed within the Department of Education or NSF.

But I feel it is most appropriately an independent public/private corporation.

Mr. **Valentine**. You think it could be made to function as you envision it without the creation of a new Federal agency or a new independent bureacracy?

Mr. **Gore**. Well, as I say, I think that—I have an open mind on any suggestions by the subcommittee that it be placed within an existing structure. But it is not intended to be a bureacracy.

It is intended—let me just outline how it is intended to function.

It is intended to have a relatively small staff and to be populated by experts in computers and in education. It is intended to review proposals from entrepreneurs, from small firms, that want to create educational computer software.

Those proposals will be evaluted for their educational excellence, their adaptability to the curricula. Also, the ease with which they can be translated into different formats.

If the board then approves a particular proposal, that proposal still cannot go forward unless and until the private venture capital market commits a sufficient amount of resources to allow it to go forward.

The corporation would then have a minority participation in that venture.

Now, why would the venture capital market be interested in participating in a firm that had gone through this process when they might not be interested without this process? Simply because the board's evaluation of the proposal lowers the risk threshold.

The venture capitalists then know that there is a much greater likelihood that this educational software effort is going to succeed. Moreover, the marketplace, made up of these thousands of school districts and schools across the country will also have their risk threshold lowered somewhat, and they are going to give more attention to software that has gone through this evaluation process by this board of experts.

Now, as I hope you can see from that analysis, it really relies upon the second judgment of the private venture capital market, and as a result, I think that the traditional concerns about institutions and bureaucracies are not the same as—in this as it would be if we were establishing a new department or a new agency.

One final point I want to stress again. That this particular model of organization has been used before and has been a fabulous success where it has been used before, and the venture capitalists are eager to participate in this kind of effort.

I have reviewed it with many of them. They are excited about this prospect.

Mr. VALENTINE. Briefly, can you give us an example of where it has been done before.

Mr. GORE. The Massachusetts High Technology Development Corp. was established by Governor Dukakis the first time he was governor. One of the board members was Chancellor Wyatt, who is now chancellor of Vanderbilt University.

He is also on the NSF Panel for supercomputers. He is one of the leading computer experts in the country. That board was established quite a few years ago.

As a result, there are now 22 highly successful high technology companies established out along route 128 near Boston that would not be there without it.

Now, private venture capitalists have put up almost all of the money. But they would not have gotten into it without the evaluation.

Moreover, I might add that the money, the initial seed money put up for that board has been paid back a couple of times over. And it has turned out to be a zero cost operation with 22 high technology companies up and going.

This is intended to have the same effect for educational computer software.

Mr. VALENTINE. Thank you. I have no further questions.

Mr. WALGREN. Thank you, Mr. Valentine.

Well, we appreciate very much your introduction to this area. It is an interesting one for any committee of the Congress, and one that our committee looks forward to talking about in great detail, and with you also.

Mr. WIRTH. Thank you very much, Mr. Chairman.

We will look forward to working with you. We appreciate being here today.

Mr. GORE. Thank you, Mr. Chairman.

Mr. WALGREN. The first panel in what will be a rather long series of witnesses—and, therefore, we want to encourage witnesses to limit themselves to something in the range of 5 minutes, and to know that their written statements will be made part of the record for full review by all the members of the committee and the staff and careful review, and that we hope you will be able to use your time to highlight those points that you really feel are the central ones, and deserve being underscored.

So the first panel, let me introduce Mr. Gary Bauer, Deputy Under Secretary of the Office of Planning, Budget and Evaluation with the Department of Education, and Dr. Richard Nicholson, acting deputy director, National Science Foundation.

Mr. Bauer, I understand you have some people with you from the Department. We welcome them to the committee.

Let's proceed with your testimony, Mr. Bauer. And again, with the thought that your full statement will be made part of the record. And we would appreciate it if you would really try to focus on the points that you feel really cry out to be made.

STATEMENT OF GARY BAUER, DEPUTY UNDER SECRETARY FOR BUDGET AND EVALUATION, DEPARTMENT OF EDUCATION, ACCOMPANIED BY CAROL A. CICHOWSKI AND ANDREW A. ZUCKER OF THE OFFICE OF PLANNING, BUDGET, AND EVALUATION

Mr. **Bauer**. Thank you, Mr. Chairman.

Let me begin by introducing my two associates. Carol Cichowski and Andrew Zucker, both of whom work with me at the Department of Education and are experts in the area of computer education and might be able to give you more details in this area.

It is a pleasure and I appreciate the opportunity to appear before you this morning to discuss the major needs for the effective use of computer technology in education and to comment on the legislation pending before this committee.

The microcomputer and its related technologies offer an exciting new resource for students and teachers. Some have said that computer technology is as revolutionary an innovation for education as the printed page.

However, educational revolutions do not take place overnight, as evidenced by the problems of adult illiteracy that we face in this Nation and throughout the world. Expectations that the computer is a panacea or that education will be improved primarily by investment in capital goods are unrealistic, in my view.

Computers do offer unique opportunities, ranging from the increasingly inexpensive and ubiquitous word processor, to emerging computer-based tutors which will help teach difficult concepts in engineering, medicine, and other fields. Technology is important both for today's students and for the future development of quality in education.

One of this administration's fundamental principles in education is to allow States and localities the freedom to develop and implement their own programs. In the response that we have seen during the last year to "A Nation At Risk," the report of the National Commission on Excellence in Education, there is ample evidence of constructive action to increase quality through State and local efforts.

Part of that response involves strategies to make effective use of new technologies. Recent reports by the American Association for School Administrators and a Department of Education sponsored study suggest that a substantial percent of chapter 1 and 2 Education Consolidation and Improvement Act block grant funds are used to purchase computer equipment, software or to support computer education activities in schools.

Further, our statistics indicate that schools are selecting a wide range of both hardware and software purchases through this block grant program. Our experience is that when this happens, the program receives the full support of the school and is not thought of as a program directed from the Federal Government. We believe that these programs developed from grassroots will last.

For this very reason, we believe that H.R. 3750, the Computer Literacy Act of 1984, is a costly, unnecessary piece of legislation. Computer literacy is being taught in all parts of the country.

Teachers and educators in every State have access to fine materials. The private sector is providing a wide range of excellent programs. The Educational Testing Service, ETS, plans to offer an advanced placement exam in computer science for high school students.

The Department also opposes the National Educational Software Act of 1984. We think there are Federal programs already in place in the Department of Education and the National Science Foundation which are adequate to stimulate the development of high quality software in those areas which pose too great a risk for the private sector, and to demonstrate effective uses of technology. Putting in place expensive new programs which involve excessive Federal control and direction of software development would be a mistake.

A number of States have already passed legislation or established administrative programs in computer education. States are increasingly active in developing software assessment and evaluation systems.

My statement contains several examples. We would be happy to provide others for the record.

Individuals at the State and local level need to become informed in order to make sound decisions. The Federal Government has a role to play, but one that is different than envisioned in the bills before this committee.

During the past few years, the Department of Education has provided substantial support for the use of computers in education, ranging from research and development of computer software to educator training programs.

One of our most important efforts consists of surveying and assessing the status of computer literacy across the Nation. The Department sponsored National Assessment of Educational Progress, NAEP, will soon be assessing a carefully selected national sample of students in this area.

We are well aware of the importance of research on how computers can best be used in the classroom, and have, therefore, established, through the National Institute of Education, a National Educational Technology Center.

The center will focus especially on the needs of students and teachers in mathematics, science, and computer education. We think this is much better than the Federal Government becoming a member of the evaluation team that judges the quality of software and hardware.

Experience shows that schools, based upon their particular circumstances, need different kinds of computers. There is no value in indiscriminate universal purchases. Local schools, districts, and each State agency are in the best position to make these choices.

Secretary Bell testified before this committee last September and mentioned some of the efforts under way in the Department in the area of technology. I would like to bring you up to date on several of our current projects.

Of special interest to this committee is our science and mathematics multimedia program "The Voyage of the Mimi." This series was developed to provide television, microcomputer software and experimental interactive videodisc programs for upper elementary school children.

I am pleased to announce that CBS publishing, Holt, Rinehart and Winston will distribute the materials for this program which is a major contribution to improving science and mathematics education.

My statement has a more detailed description of that program.

The "Voyage of the Mimi" is the latest in a long line of highly successful educational television series supported with Federal funds, stretching back to 1968 and "Sesame Street" and including for "3-2-1 Contact". New authorizations are not needed for such programming.

Through our center for Libraries and Educational Improvement, CLEI, the Department has supported development of three high risk, innovative software programs which focus on teaching and learning of basic skills. This software has been developed in conjunction with schools.

The programs have been field tested in numerous classrooms across the Nation. These are 3-year development projects designed to go beyond the simple drill and practice that characterize so much early software.

The programs are described in detail in my statement.

These programs were high risk projects that required expert teams for development, and the involvement of thousands of students. The formula has worked very well.

Two of the panel members who will testify today are our partners in these developments. Dr. Paul Horwitz of Bolt, Beranck, and Newman, Inc., represents the highly qualified team that developed the Quill writing program and Mr. Harry McQuillen represents CBS Publishing, the distributor of the "The Voyage of the Mimi."

Over the past 3 years, the Department has also been active in working with State and local governments to disseminate the best educational technology applications. Last year, under the Secretary's Discretionary Program, awards were made to 12 school systems to demonstrate the implementation of educational technology.

These systems are located in all regions of the Nation. The demonstrations include close industry/school cooperation.

Business and industry are also becoming active partners in computer literacy programs, as they are in a variety of other education programs. My statement includes several examples. Again, we would be happy to provide more for the record.

As you can see, the Department of Education has been actively involved in many ways in helping students to benefit from the computer revolution. In general, we believe we have adequate resources and program authorities for this purpose.

Our budget request for fiscal year 1985, however, does include a $6 million increase for the National Institute of Education, a portion of which is earmarked for activities in technology. This reflects our view that research is essential if we are to make the best possible use of emerging technologies.

In addition, we have asked for a major increase in the chapter II block grant program. Using that money for computer related items is a permissible use and many schools have taken advantage of it.

As I stated previously, the administration does not support these two pieces of legislation. They are excessively costly, and would mandate a level of Federal involvement and control which is inappropriate.

The Federal Government has a limited, although important, role to play in this area. Current programs within the Department of Education and the National Science Foundation are adequate to address these needs.

If Congress wishes to act in this area, we would urge support for our proposal for a substantial increase in chapter II funds.

Thank you very much.

[The prepared statement and biographical sketch of Mr. Bauer follow:]

STATEMENT OF

GARY L. BAUER
DEPUTY UNDER SECRETARY
FOR
PLANNING, BUDGET AND EVALUATION
U.S. DEPARTMENT OF EDUCATION

BEFORE THE
SUBCOMMITTEE ON SCIENCE,
RESEARCH AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

JUNE 5, 1984

Mr. Chairman and Members of the Subcommittee, I appreciate the opportunity to appear before you this morning to discuss the major needs for the effective use of computer technology in education and to comment on the legislation pending before this Committee.

The microcomputer and its related technologies offer an exciting new resource for students and teachers. Some have said that computer technology is as revolutionary an innovation for education as the printed page. However, educational revolutions do not take place overnight, as evidenced by the problems of adult illiteracy that we face in this Nation and throughout the world. Expectations that the computer is a panacea or that education will be improved primarily by investment in capital goods are unrealistic, in my view.

Computers do offer unique opportunities, ranging from the increasingly inexpensive and ubiquitous word processor, to emerging computer-based tutors which will help teach difficult concepts in engineering, medicine, and other fields. Technology is important both for today's students and for the future development of quality in education.

One of this Administration's fundamental principles in education is to allow states and localities the freedom to develop and implement their own programs. In the response that we have seen during the last year to "A Nation At Risk," the report of the National Commission on Excellence in Education, there is ample evidence of constructive action to increase quality through state and local efforts. Part of that response involves strategies to make effective use of new technologies. Recent reports by the American Association for School Administrators and a Department of Education sponsored study suggest that a substantial percent of Chapter 1 and 2 Education Consolidation and Improvement Act block grant funds are used to purchase computer equipment, software or to support computer education activities in schools. Further, our statistics indicate that schools are selecting a wide range of both hardware and software purchases through this block grant program. Our experience is that when this happens, the program receives the full support of the school and is not thought of as a program directed from the Federal government. We believe that these programs developed from grassroots will last.

For this very reason, we believe that H.R. 3750, the Computer Literacy Act of 1984 is a costly, unnecessary piece of legislation. Computer literacy is being taught in all parts of the country. Teachers and educators in every state have access to fine materials. The private sector is providing a wide range of excellent programs. The Educational Testing Service (ETS) plans to offer an Advanced Placement exam in computer science for high school students.

The Department also opposes the National Educational Software Act of 1984. We think there are Federal programs already in place in the Department of Education and the National Science Foundation which are adequate to stimulate the development of high quality software in those areas which pose too great a risk for the private sector, and to demonstrate effective uses of technology. Putting in place expensive new programs which involve excessive Federal control and direction of software development would be a mistake.

A number of states have already passed legislation or established administrative programs in computer education. States are increasingly active in developing software assessment and evaluation systems. Illustrative of these efforts are:

- Minnesota has passed and appropriated funds for a $6 million a year program that includes teacher training, planning, software and hardware acquisition and model demonstration programs.
- New York has established a Center for Learning Technology which has developed criteria and standards that may be used by schools to assess and select instructional hardware.
- Florida has passed an extensive computers in education legislation package that includes guidelines and plans for each school system.
- Tennessee has developed a statewide policy on computers in education that is about to become operational.

- Virginia has instituted a statewide program that uses television to train teachers in the latest state of the art technology for the classroom.
- California has developed a network of 19 educational computing centers throughout the state that provide both training and resources for teachers within each region.
- Oregon's Educational Computer Consortium (OECC) that includes nearly all of its local educational agencies, has in the past several years been engaged in evaluating and selecting software.

Individuals at the state and local level need to become informed in order to make sound decisions. The Federal government has a role to play, but one that is different than envisioned in the bills before this Committee.

During the past few years, the Department of Education has provided substantial support for the use of computers in education, ranging from research and development of computer software to educator training programs. One of our most important efforts consists of surveying and assessing the status of computer literacy across the Nation. The Department sponsored National Assessment of Educational Progress (NAEP) will soon be assessing a carefully selected national sample of students in this area.

We are well are of the importance of research on how computers can best be used in the classroom, and have therefore established, through the National Institute of Education, a National Educational Technology Center. The Center will focus especially on the needs of students and teachers in mathematics, science, and computer education. We think this is much better than the Federal government becoming a member of the evaluation team that judges the quality of software and hardware. Experience shows that schools, based upon their particular circumstances, need different kinds of computers. There is no value in indiscriminate universal purchases. Local schools, districts, and each state agency are in the best position to make these choices. To help states and local school districts implement strategies to improve the quality of education, the Department asked for more funds under Chapter II. With this increase, state and local agencies could initiate new programs including technology, with the decision being made at the operating level, where the learning and teaching takes place.

Secretary Bell testified before this committee last September and mentioned some of the efforts under way in the Department in the area of technology. I would like to bring you up to date on several of our current projects.

Of special interest to this Committee is our science and mathematics multi-media program "The Voyage of the Mimi." This series was developed to provide television, microcomputer software and experimental interactive videodisc programs for upper elementary school children. I am pleased to announce that CBS Publishing, Holt, Rinehart and Winston will distribute the materials for this program, which is a major contribution to improving science and mathematics education. The program will be aired on PBS next September. The computer programs developed for this project are at the leading edge of software development. The computer programs include:

- A program which turns the computer into a series of scientific instruments. There is a temperature probe, light probe and sound probe. These are inexpensive sensors that attach to the computer and display data graphically on the screen.
- A simulation that requires teamwork to find a whale caught in a fisherman's net. Each team player is responsible for a separate job, as though they were members of a ship's crew, and they must cooperate to find their own location, plot a course to rescue the whale, and do the necessary mathematics and navigation.

The "Voyage of the Mimi" is the latest in a long line of highly successful educational television series supported with Federal funds, stretching back to 1968 and "Sesame Street" and including for "3-2-1 Contact!" New authorizations are not needed for such programming.

Through our Center for Libraries and Educational Improvement (CLEI), the Department has supported development of three high-risk, innovative software programs which focus on teaching and learning of basic skills. This software has been developed in conjunction with schools. The programs have been field-tested in numerous classrooms across the Nation. These are three-year development projects designed to go beyond the simple drill and practice that characterize so much early software. Once these developmental projects were field-tested and validated, based upon competency testing of the students, bids were obtained from commercial distributors for release of the products to the open market. The programs are:

- The QUILL program, which is a program in written communications for the upper elementary grades, was developed by Bolt, Beranak, and Newman of Cambridge, Massachusetts and will be distributed by D.C. Heath Publishing Company this summer.
- IRIS, which is a comprehensive reading program for the upper elementary grades, was developed by the WICAT FOUNDATION and will be distributed by WICAT, Inc. in the Fall of 1984. As a result of Department funding, WICAT stimulated the additional development of reading materials and adult literacy programs. Even though the WICAT FOUNDATION was the developer of this material, WICAT, Inc. had to bid for the distribution rights in competition with other distributors. WICAT estimates that this project attracted $15 million in venture capital for the production of reading materials at all levels. Again, the materials were designed to go beyond the beginning steps of computer uses in the classrooms.
- The TABS project, which was developed for upper elementary grades in mathematics by Ohio State University, is in its final stages of negotiation with a nationally known distributor.

These programs were high risk projects that required expert teams for development, and the involvement of thousands of students. The formula has worked very well. Two of the panel members who will testify today are our partners in these developments. Dr. Paul Horwitz of Bolt, Beranak, and Newman, Inc., represents the highly qualified team that developed the QUILL writing program and Mr. Harry McQuillen represents CBS Publishing, the distributor of the "The Voyage of the Mimi."

Over the past three years, the Department has also been active in working with state and local governments to disseminate the best educational technology applications. Last year, under the Secretary's Discretionary program, awards were made to 12 school systems to demonstrate the implementation of educational technology. These systems are located in all regions of the Nation. The demonstrations include close industry/school/ cooperation.

Business and industry are also becoming active partners in computer literacy programs.

- Digital Corporation has entered into a project with the Lynnfield, Massachusetts schools where they are training school personnel in instructional design on computer controlled videodiscs. This two year project will produce and test an elementary earth science program.
- IBM has entered into an extensive multi-million dollar program with both elementary and secondary schools, providing equipment, software and training. One of the more exciting programs is their "Write to Read" program for beginning readers.
- Radio Shack/Tandy Corporation has had an extensive teacher training program available to teachers and school administrators for several years.
- Apple Corporation has made several grants to educators for development of quality software and other applications of technology in education. Some of the more sophisticated software development has emerged from this program. In the state of California, Apple Corporation has distributed 10,000 computers to schools.

As you can see, the Department of Education has been actively involved in many ways in helping students to benefit from the computer revolution. In general, we believe we have adequate resources and program authorities for this purpose.

Our budget request for fiscal year 1985 however, does include a $6 million increase for the National Institute of Education, a portion of which is earmarked for activities in technology. This reflects our view that research is essential if we are to make the best possible use of emerging technologies.

As I stated previously, the Administration does not support these two pieces of legislation. They are excessively costly, and would mandate a level of Federal involvement and control which is inappropriate. The Federal government has a limited, although important, role to play in this area. Current programs within the Department of Education and the National Science Foundation are adequate to address these needs. If Congress wishes to act in this area, we would urge support for our proposal for a substantial increase in Chapter II funds.

Mr. Chairman, this concludes my statement. I would be happy to respond to your questions.

BIOGRAPHICAL DATA

Gary L. Bauer

Gary L. Bauer, Deputy Under Secretary for Planning, Budget and Evaluation at the Department of Education, was sworn in by Secretary of Education, T. H. Bell on October 13, 1982.

Before coming to the Department of Education, Bauer served in the White House Office of Policy Development, first as a policy analyst and then as policy advisor to the President and, finally, as Deputy Assistant Director of Legal Policy. In those positions, he worked closely with the Human Resources Cabinet Council on a wide range of education and social issues.

Bauer served in the Reagan-Bush Campaign as a senior policy analyst and worked in the Office of the President-Elect as Assistant Director for Policy/Community Services Administration.

From 1973 to late 1980, he was in the Washington Office of the Direct Mail/Marketing Association, a 2,000 member company trade association, eventually becoming Director of Government Relations in 1976. He was responsible for a major industry self-regulatory program that has been hailed as a model of how business can avoid government regulation through aggressive self-policing. He also has served on task forces of the U.S. Chamber of Commerce and the National Association of Manufacturers, dealing with regulatory issues.

From 1971 to 1973, he was Director of Research at the Republican National Committee and worked on a variety of domestic issues, including education policy.

In 1968, he received his B.A. degree from Georgetown College in Georgetown, Kentucky and a Juris Doctor from Georgetown Law School, Washington, D.C. in 1973.

Mr. **Walgren**. We appreciate that statement.

Dr. Nicholson.

STATEMENT OF DR. RICHARD S. NICHOLSON, ACTING DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. **Nicholson**. Thank you. I would like to try to summarize my statement.

I would like to do two things. First, give you a very brief outline or summary of what the NSF role has been in this area in the past, and what it is today, right now, and then try to make a few observations from the NSF perspective on H.R. 3750 and 4628.

NSF has had a role and it has been active in this area for a long, long time, 20 years at least probably—long before cheap electronics made the micro or personal computer the ubiquitous thing that it is today and on everyone's mind apparently. NSF had supported activities in education.

For 15 or 20 years we have successfully supported research development and the dissemination of computer-based educational systems, materials, courseware, and language.

I think there is one particularly powerful example of the early NSF role in this area. Anyone familiar with the computers that are used in homes and schools today knows that they are all using a programming language called BASIC. BASIC language is the backbone and the industry standard for all personal computers.

They all operate on a language called BASIC. It is a form of software, actually. A fact that is much less known is that the BASIC language was developed under a grant from the National Science Foundation educational activities in the early 1960's.

So this language that everyone uses today actually came from a grant some 20 years ago out of the National Science Foundation to Dartmouth College to develop the BASIC language. Similarly today, if you go in a classroom in the elementary grades, where children are using computers, you are apt to see them using a language called LOGO. This is a language that also was developed through grants from the National Science Foundation educational programs.

There are other examples. The PLATO program that Control Data Corp. invested $1 billion in, and it is used extensively in military training and schools. The concept work was supported by the NSF.

The so-called intelligent video disc, which makes use of both computers and video disc technology and has tremendous potential in terms of the future in education, also has been funded by the National Science Foundation.

More recently, our Commission, as you know, as has been referred to earlier this morning, looked into this area and stated its belief also that the new information technologies offer great potential for improving the classroom environment, particularly in mathematics, science, and technology.

This Commission recommended specifically that NSF assume a leadership role in this area by supporting prototype demonstrations, by fostering the dissemination of information on model materials and practices, and by supporting research on the integration of educational technologies within the curriculum.

That is essentially—we have essentially followed their recommendations in the programs we have at NSF right now today. The Commission viewed NSF's role then as one of leadership or a facilitator for the development of these technologies.

However, the actual providing or incorporation of educational technologies into the classroom is included in our Commission's recommendation that are directed at State and local governments and the private sector, not the Federal Government.

As you know, Mr. Chairman, we have reestablished science education activities recently at NSF. We already now are supporting a number of activities in this general area. I thought it might be helpful to cite just a few illustrative examples of the kind of things NSF is supporting today in this area.

For example, in our honors program, this summer 30 junior high school teachers at Chestnut Hill College in Pennsylvania will be exposed in course work in BASIC, the language I referred to earlier, and another language called PASCAL, and in addition we will design ways to evaluate computer software.

Another example, 25 elementary school teachers will use microcomputers to learn how new mathematical techniques for problem solving and simulation at Illinois State University. And a group of secondary school teachers will investigate new ways to teach mathematics via the computer at the University of Texas at San Antonio.

Another one of our programs, materials development program, we have recently funded the American Statistical Association to develop computers to teach probability and statistics. At Eastern Michigan University, faculty and secondary school teachers will develop laboratory experiments and instructional units for computer-based chemistry courses.

The Consortium for Mathematics and its Applications is developing materials in mathematics that incorporate the most recent use of computer technology for teaching and learning for preparing some 15,000 teachers.

The materials developed in all of these projects will receive national dissemination as a requirement of the program.

I also should mention business and industry, as our commission recommended, are doing their part. The March 1984 issue of Datamation reports that the Apple Computer Corp. has offered a complete system to every school in the State of California.

It is reported they have given away some 9,000 to 10,000 systems worth perhaps $20 million. IBM has given 1,500 of its personal computers through its PC literacy program to 89 schools and 12 colleges in New York, Florida, and California and also trains teachers from these institutions for an estimated cost of $8 million.

The Tandy Corp. offers free courses in BASIC and a 24 hour educational program at its 420 nationwide computer centers to any teacher, whether or not he or she uses Tandy's Radio Shack computers.

It is reported they have trained an estimated 150,000 teachers in the last 3 years. Tandy also has mailed out free of charge an audiovisual presentation training program about computers in the classroom to over 103,000 schools.

Mr. Chairman, I hope that by this brief background I have shown that NSF in this particular area has, in fact, a distinguished track record that goes back a long time before this particular issue was so much in the public consciousness, and it is an area in which we intend to maintain our leadership role in the years ahead.

So in that context, then, I would like to make a few comments on H.R. 3750 and 4628.

First, I want to be clear that we think the ultimate aims of these bills are good, they are very compatible with the kind of things I have just discussed that the Foundation has done and is doing right now. We only question whether these mechanisms are the best way to achieve those aims.

By that, I mean we feel that existing Federal programs and new State programs already allow educators to accomplish many of the features included in the proposed bill. In addition to Federal programs, many States have now initiated vigorous programs of their own and others are developing them as well.

The April 1984 issue of Electronic Learning reports that 17 States already have passed laws requiring or recommending some form of computer literacy and instruction in their K-12 schools. Similarly bills are under consideration in a good many more States.

Minnesota has set aside funds for software development and has provided incentives to use quality software. California and Minnesota have set up software demonstration centers so that teachers can try out materials and software.

Additional Federal efforts must be careful not to undercut the many excellent State programs and private initiatives that are just getting underway and the many cooperative efforts initiated by the business and academic community.

Indeed, we believe that the current mix of governmental programs and private initiatives is about right.

Title II of 3750 provides for the support of summer institutes by the National Science Foundation. We would note that NSF already is supporting such institutes, I mentioned some, and provides stipends, travel and per diem for the teachers; a much more liberal and necessary kind of support than provided for in the bill.

And as I already noted, the private sector and universities are now beginning to provide extensive training programs of their own.

Title III of that bill provides for information dissemination. In my written statement I list a rather large number of examples of dissemination centers and clearinghouses that are already in existence, more that are being established with Foundation support.

Finally, let me comment briefly on H.R. 4628, which provides for the establishment of a National Education Software Corporation. It is not clear whether the goal of this Corporation is to make money or to provide materials whose development would be of high risk to investors.

Should materials be designed for small special markets like the handicapped and the gifted, or for the large general purpose market such as reading and arithmetic?

The market audience and specialization of materials will greatly affect obviously the investments and benefits that will come.

Is the Corporation to provide materials for those who can pay or provide materials for those who may benefit most from their use? With such a small capitalization of the Corporation, the goal may by necessity may be to support materials that are likely to make a large profit. If not private sector investments will be small, especially if there is no likelihood of high profits for high risk areas.

Other less expensive approaches might be considered. For example, in February 1982, NSF embarked on a pioneering program involving industry and universities. The NSF industry cooperation for science and engineering education using computers supported creative projects to develop innovative prototypes of computer-based instructional materials for grades 10, 11, and 12 and early college years. Computer vendors donated an estimated million dollars worth of equipment, and NSF and universities provided additional funds and resources to develop these materials.

In any event, development of any of these materials will be expensive and costly. The costs of developing a critical mass of high quality software are relatively high.

It is estimated that 4,000 hours of courseware is needed for a critical mass at the precollege level if students are to have access to the computer for at least a half hour per day. High quality computer software can cost as much as $1 million a course.

Rule of thumb estimates place costs at $30,000 per contact hour. Rather than provide large sums of money so that a few high quality courses can be developed, some feel that our money might be better spent in developing so-called authoring languages and authoring aids with a goal for driving down the cost of producing high quality materials by perhaps a factor of 10. These would be new kinds of languages like the BASIC language that would let more people develop their own educational package in a cost effective way.

In this way we could produce far more high quality materials and increase the number of authors. This approach might have the added advantage of helping commercial developers, educators, and individual teachers who may want to develop their own special purpose courses. The Foundation is embarking on such a course right now by encouraging the development of such new authoring languages.

While we agree with the goals of the bills, we believe we already have ample authority and resources to achieve them under existing programs.

This concludes my statement.

[The prepared statement and biographical sketch of Dr. Nicholson follow:]

National
Science
Foundation

STATEMENT BY

DR. RICHARD S. NICHOLSON
ACTING DEPUTY DIRECTOR
NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE AND TECHNOLOGY

U. S. HOUSE OF REPRESENTATIVES

JUNE 5, 1984

Mr. Chairman and Members of the Committee,

I wish to thank you for the opportunity to appear before you to discuss the major needs for the effective use of computer technology in education and to comment on the extent to which the proposed legislation meets these needs.

The National Science Foundation has long supported computing in education. NSF has within its mission the responsibility for fostering and supporting the development and use of computers and other scientific methods and instruments primarily for research and education in the sciences. We have supported research, development and the dissemination of computer-based educational systems, materials, courseware and languages for well over a decade. For example, the Foundation provided a grant to Dartmouth College to create the language BASIC, probably the most widely used language in education. Many years of support for the LOGO language for children and PLANIT, an authoring language, have all made significant impacts on the educational uses of computing. NSF proof-of-concept support for the PLATO and TICCIT systems and intelligent-videodisc systems has demonstrated the educational effectiveness of these systems and has helped recruit commercial interest and support for them. Software and courseware, such as the Huntington simulations and computer literacy model programs, have contributed to the creation of high quality materials and advancement of the field.

In April 1982, the National Science Board established an autonomous Commission on Precollege Education in Mathematics, Science and Technology, whose purpose was to propose remedies to the perceived dire state of American elementary and secondary education in these fields. One of the major findings of the NSB Commission was that the new information technologies offer great potential for improving the classroom environment, particularly in mathematics, science and technology. Based on that finding, the Commission recommended actions for each of the different sectors of society to foster the realization of that potential.

One major recommendation was that the National Science Foundation once again take a leadership role in this area, by supporting prototype demonstrations, by fostering the dissemination of information on model materials and practices, and by supporting research on the integration of educational technologies with the curriculum. NSF's leadership role was viewed by the Commission as a "guide" for, or facilitator of, the development of educational technologies. Providing for the actual incorporation of educational technologies into the classroom was, I might add, included in the recommendations directed at state and local governments and the private sector.

At the same time the Commission was issuing its report, the National Science Board reaffirmed NSF's intention to take the lead in developing programs at all levels of education in mathematics, science and technology, and the Director re-established the Directorate for Science and Engineering Education. The Division of Precollege Education in Science and Mathematics, which now administers the technology program, provides support for computer technology in education in several ways.

1. Improved Instructional Materials

   Eligible activities include the development of high quality materials and the introduction of new scientific or technological advances, improved methods of delivering instruction, including technology-based materials, software, computer simulations of laboratory experiments, and television or videodisc-based materials.

2. Improved Methods of Teacher Development

   Local and regional teacher development and honors workshops for precollege teachers of science and mathematics are eligible for support and may include courses and seminars dealing with educational technology, such as computers or telecommunications. Undergraduate preparation of teachers is also included.

3. Research in Teaching and Learning

   Basic and applied research on information processing models as they relate to science teaching and learning, the effects of incorporating information processing technology into the traditional school setting and the distribution and adoption of technologies are all encouraged.

4. Application of New Technologies

   Research and development on advanced technologies, particularly the computer, as educational and instructional tools for students and their teachers can be supported. Support is also provided for exploration, development, and proof-of-concept demonstration of advanced computer and telecommunications technologies, as well as innovative computer-based concepts and applications. The program supports the development of computer-based systems for precollege science and mathematics education which augment human intelligence, intuition and problem solving; development, testing and evaluation of systems that offer exceptional promise of educational effectiveness and efficiency, and support of mechanisms to facilitate the widespread use of educational technology.

The Division of Precollege Education in Science and Mathematics has already funded projects designed to enhance computer literacy in schools across the United States and the use of the computer in the classroom for instruction in traditional subjects. These projects are designed to engage teachers in a wide variety of activities that foster the use of computers in schools.

Under the honors program, the following kinds of activities are presently taking place: At Chestnut Hill College in Pennsylvania, thirty junior high school teachers will be exposed to course work in BASIC and Pascal and, in addition, will design ways to evaluate computer software; twenty five elementary school teachers will use microcomputers to learn new mathematical techniques for problem solving and simulation at Illinois State University; and finally, a group of secondary school teachers will investigate new ways to teach mathematics via the computer at the University of Texas at San Antonio.

The materials development program in the Directorate has funded three major projects related to the use of the computer. One project, awarded to the American Statistical Association, deals with using the computer to teach probability and statistics; at Eastern Michigan University, faculty and secondary school teachers will develop laboratory experiments and instructional units for computer-based chemistry courses, and the Consortium for Mathematics and its Application (COMAP) is developing materials in mathematics that incorporate the most recent use of computer technology for teaching and learning for preparing 15,000 teachers. The materials developed in these projects will receive national dissemination.

The Foundation believes that the health of computers in education is excellent. There has been an extraordinary growth of computers in precollege education. In 1980, the National Center for Educational Statistics reported that there were 52,000 terminals and microcomputers in the schools. Market Data Retrieval now reports that 325,000 computers will be in the schools by September of this year. 62.4% of our elementary schools, 80.5% of our junior high schools and 86.1% of our high schools now have at least one computer.

Business and industry are also doing their part. The March 1984 issue of DATAMATION, for example, reports that the Apple Computer Corporation has taken advantage of the tax incentives offered companies in California and has offered a complete system to every school in the State. Almost all schools have accepted. It is reported that Apple has given approximately 9,250 systems worth 20 million dollars and has received an estimated 1.5 million dollars in tax breaks from the State. IBM has given 1,500 personal computers through its PC literacy program to 89 schools and 12 colleges in New York, Florida and California and also trains teachers from these institutions for an estimated cost of eight million dollars. The Tandy Corporation offers free courses in BASIC and a twenty hour educational program at its 420 nationwide computer centers to any teacher whether or not he or she uses Tandy's Radio Shack computers. It is reported that they have trained an estimated 150,000 teachers in the last three years. Tandy has also mailed out, free of charge, an audiovisual presentation training program about computers in the classroom to over 103,000 schools.

High quality materials and courseware are now appearing on the market. In Fiscal Years 1980 and 1981, as a stimulus to the market, the National Science Foundation and the National Institute of Education jointly funded a program to develop Precollege Mathematics Using Computers. The program was administered by NSF and produced many innovative projects in computer-based mathematics. These materials are now being widely disseminated through commercial publishers and non-profit clearinghouses.

I would like to comment on the two bills before the Committee: H.R. 3750, a bill to promote computer literacy among elementary and secondary school students and their teachers, and H.R. 4628, a bill to establish a National Education Software Corporation.

First, we think the ultimate aims of the bills are good, although we question whether these mechanisms are the best ways to achieve those aims. Computers already permeate our society and greatly affect our daily lives. If we agree that the Nation should prepare its children for the information world in which they are going to live, familiarity with computers should be included in the curriculum. However, existing Federal programs and new state programs already allow educators to accomplish all of the features included in the proposed bills. The Foundation's current authority permits it to support basic research, applied research, materials development, dissemination, and prototyping on new advanced computer technologies for education and teacher training. In addition to Federal programs, many states already have initiated vigorous programs of their own and others are now developing them. The April 1984 issue of Electronic Learning reports that a survey of state education agencies finds that 17 states have already passed laws requiring or recommending some form of computer literacy instruction in their K-12 schools. Similar bills are under consideration in a good many more states. The State of Minnesota has set aside funds for software development and has provided incentives to use quality software. California and Minnesota both have set up software demonstration centers so that teachers can try out materials and software.

Additional Federal efforts are likely to undercut the many excellent state programs and private initiatives that are just getting under way and the many cooperative efforts initiated by the business and academic community. We believe the current mix of governmental programs and private initiatives is a proper one. It will lead to a solid foundation that will provide the high quality materials necessary for students in our schools to achieve excellence.

We are also concerned about equity. Under Title I, Acquisition of Hardware, Section 10 (a)(1) "Funds are provided first to those schools with the least computer hardware per student." Under this legislation, schools no matter how affluent and who may be well able to pay for equipment may benefit from equipment acquisitions not because they are needy but because they were slow to adopt new technology. Under Title II, teacher training institutes are provided. NSF already provides such institutes and permits stipends, travel and per diem for teachers---a much more liberal and necessary support than provided in the bill. In addition, as noted earlier, the private sector and universities are beginning to provide training programs.

Title III provides for information dissemination. Many centers and clearinghouses already have been established to disseminate and evaluate courseware and software. For example, CONDUIT, Iowa City, Iowa, creates reviews and distributes software. MicroSIFT, based at the Northwest Regional Educational Laboratory in Portland, Oregon is a clearinghouse for descriptive and evaluative information about microcomputer-based software and materials in education. Microcomputer Educational Applications Network provides information on microcomputer applications. EPIE (Educational Products Information Exchange) also provides a direction and evaluation guide of computer programs available for national distribution. NSF supported Project Seraphim at Eastern Michigan University produces a Computers in Chemical Education Newsletter which contains information about software in chemistry. There are many software evaluation services that specialize on more specific categories of courseware materials. The Department of Education's recent award to Harvard to establish an educational technology center will also provide additional resources for research on the use of computers in education. Therefore, it is clear that the clearinghouse and dissemination needs are currently being met.

Second, bill H.R. 4628 provides for the establishment of a National Education Software Corporation. Clearly, both Federal and venture capital are needed if high quality materials are to be developed in sufficient quantity. However, in this case, government and private investments may work at cross purposes.

It is not clear whether the goal of the Corporation is to make money or to provide materials whose development would be of high risk to investors. Should materials be designed for small, special markets (e.g. handicapped, gifted) or for the large general purpose markets such as reading and arithmetic? The market audience and specialization of materials will greatly affect the investments and benefits. Is the Corporation to provide materials for those who can pay, or provide materials for those who may benefit most from their use? With such a small capitalization of the Corporation, the goal may, by necessity, be to support materials that are likely to make a large profit. If not, private sector investments will be small, especially if there is no likelihood of high profits for high risks.

Other less expensive approaches might be considered. For example, the National Science Foundation, in February of 1982, embarked on a pioneering program involving industry and universities. "NSF/Industry Cooperation for Science and Engineering Education Using Computers" supported creative projects to develop innovative prototypes of computer-based instructional materials for Grades 10, 11 and 12 and early college years. Computer vendors donated equipment valued at close to a million dollars, and NSF and the universities provided additional funds and resources to develop software and materials in science education. We believe this program has been successful and could easily be replicated in the various states.

Any materials development program will be expensive. The costs of developing a critical mass of high quality materials are relatively high. It is estimated that 4000 hours of courseware is needed for a critical mass at the precollege level if students are to have access to the computer for an ideal half-an-hour-per-day. High quality computer courseware can cost as much as a million dollars a course. Rule-of-thumb estimates place costs at $30,000 per contact hour. Rather than provide large sums of money so that a few high quality courses can be developed, some feel that our money might be better spent in developing authoring languages and authoring aids with a goal for driving down the costs of producing high quality materials by a factor of ten. In this way, we could produce far more high quality materials and increase the number of authors. This approach also has the added advantage of helping commercial developers, educators and individual teachers who may want to develop their own special purpose courses. The Foundation is embarking on such a course by encouraging the development of new authoring languages.

In summary, the computer has the potential for having an enormous impact upon education. However, many new innovations and applications of technology also carry the possibility of concomitant risks which, we believe, argues against rushing into large-scale production systems that may soon be obsolete or may do great harm to the educational process. We feel that this calls for proceeding in a cautious, systematic way to build a solid foundation based on research and development findings, to ensure that education will ultimately benefit from these efforts. While we agree with the goals of the bills, we believe we have ample authority and resources to achieve them under existing programs.

Accordingly, we oppose enactment of both H.R. 3750 and H.R. 4628.

RESUME

Richard S. Nicholson

Personal Data

Birthplace : Des Moines, Iowa
Birthdate : April 5, 1938
Marital Status : Married
Military Status: Honorable Discharge, USNR, May 9, 1963

Education

BS in chemistry, Iowa State University, Ames, Iowa, 1960
PhD in chemistry, University of Wisconsin, Madison, Wisconsin, 1964.

Positions Held

Staff Director, National Science Foundation, 1983-Present
Acting Deputy Director, National Science Foundation, 1983-present.
Executive Director, National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1982-1983
Director, Chemistry Division, National Science Foundation, 1977-1982.
Deputy Assistant Director for the Mathematical and Physical Sciences, National Science Foundation, 1980-1982.
Director, Division of Information Systems, National Science Foundation, 1979-1980.
Senior Planning Officer for the Mathematical and Physical Sciences, National Science Foundation, 1978-1979.
Special Assistant to the Director of the National Science Foundation, 1976-1977.
Deputy Director, Chemistry Division, National Science Foundation, 1975-1976.
Director, Chemical Instrumentation Program, Chemistry Division, National Science Foundation, 1971-1975.
Director, Chemical Analysis Program, Chemistry Division, National Science Foundation, 1970-1971.
Associate Professor of Chemistry, Michigan State University, 1967-1970.
Assistant Professor of Chemistry, Michigan State University, 1964-1967.
Postdoctoral Research Associate, University of Wisconsin, 1963-1964.

Professional Activities and Honors

Dow Fellow (1962-1963): National Science Foundation Fellow (1961-1962); Eastman Kodak Scientific Award (1964, $1,000); National Councilor for Michigan State University Section, American Chemical Society (1965-1968); Chairman, Michigan State University Section, American Chemical Society (1968-1970); Phi Eta Sigma (1968); Sigma Xi, (1969); American Chemical Society; American Association for the Advancement of Science; Chairman, Symposium on Bioelectrochemistry (1975); member, Bioelectrochemistry Liaison Committee of the Electrochemistry Society (1975); member, National Meetings Program Committee of the American Chemical Society, Division of Education (1975); William A. Jump Meritorious Award for Exemplary

Achievement in Public Administration (1975); Executive Development Program (1975); Executive Secretary, The President's Committee on the National Medal of Science (1976-to present); Representative Federal Council on Arts and Humanities (1976-1977); Nominations Committee, Chemical Society of Washington (1977); Member, Office of Science and Technology Policy's Working Group on Basic Research in the Department of Energy (1978); The NSF's Meritorious Service Award (1978, the Agency's second highest honor); Consultant, Office of Science and Technology Policy, President's Message to Congress on Science and Technology (1979); The NSF's Superior Accomplishment Award (1979, $1,000 "for work on the Master Grant Project"); Consultant to Office on Science and Technology Policy for President's Message on Industrial Innovation (1979); Office of Science and Technology Policy Advisory Panel on the Cooperative Automative Research Program (1979); Fellow of the American Association for the Advancement of Science (1979); Editorial Advisory Board, Analytical Chemistry (1980-1982); NSF's Distinguished Service Award (1980, the Agency's highest honor); Senior Executive Service Bonus (1981, $10,000); Consultant, Procter and Gamble Company, University Exploratory Research Program (1981); Committee on Chemistry of the American Chemical Society (appointed by ACS President in 1982); Senior Executive Service Award (1982, $5,000); Presidential Distinguished Rank (the Government's highest civil service honor, conferred by the President at the White House, November, 1982); Iowa State University Distinguished Alumni Award (June, 1983); Inaugural Whitehead Lecturer (University of Georgia, February, 1984).

Publications

Twenty-six publications in refereed scientific journals. The publications are in electrochemistry and mass spectrometry. The electrochemical research focuses on the theoretical development and applications of cyclic voltammetry, including computer modeling, and computerized instrumentation. The mass spectrometry involves applications of chemical ionization.

Mr. **Walgren**. Thank you, Dr. Nicholson.

Let me ask Mr. Bauer. You indicate that much is being done. Congressman Wirth, of course, took another view.

The $6 million increase that you are recommending for the National Institute of Education, a portion of that being for technology, how much is being done in the National Institute of Education in terms of identifiable funds that would go to this function?

Mr. **Zucker**. Mr. Chairman, currently more than $5 million is being obligated through NIE for technology related projects.

Mr. **Walgren**. And can you define a little further technology related projects?

Mr. **Zucker**. The largest investment is the newly established educational technology center at Harvard University, which is focusing on the use of computers in mathematics, science and computer education.

Mr. **Walgren**. How much money does that involve?

Mr. **Zucker**. Over a 5-year period, it is a contract for 5 years, in excess of $7 million.

Mr. **Walgren**. And so much of the $5 million that you are allocating this year would go to that one center?

Mr. **Zucker**. It is about $700,000. There are a variety of other projects which are being supported. One which was mentioned in the testimony is the National Assessment of Educational Progress, or NAPE, which will be doing an assessment of computer literacy in its next round, 1985-86. And there are also many other projects being supported.

We could supply that for the record.

Mr. **Walgren**. That study has yet to occur at this point. Isn't that correct?

Mr. **Zucker**. NAPE has not yet assessed computer literacy.

Mr. **Bauer**. Mr. Chairman, in addition, a large portion of our budget that can be used in the computer-related area is the chapter II block grant for which we are seeking a major increase this year, and the Secretary has been very aggressive in trying to encourage local school districts to, in fact, utilize that block grant money for this area, for computer-related education.

Mr. **Walgren**. What is the measure of the use of that money in this area? Do you have any——

Mr. **Bauer**. We have some preliminary——

Mr. **Walgren**. How much money is going in that direction?

Mr. **Bauer**. We have some preliminary studies. As you know, the block grant is not that old. We want to view some further studies about where money is going.

The last measurement we have seen, indicated that about half the districts were using block grant funds for either the purchase of computers or software, and other computer-related education activities.

Our view is that if, in fact, local communities perceive this to be as much of a need as we do here in Washington, they will in fact take this money that has very few strings on it and use it for a high priority area. And if they are not using it for that, then they have made a decision at the state and local level that they have other needs that take preeminence over this need.

Mr. **Walgren**. I understand. And yet, the result may be a very patchwork exposure to computers—if some educational systems are addressing other, albeit in their own view, more important avenues at that point.

But, from a national level, we would then see a patchwork, would we not, of some school systems having a very substantial program in this area and some schools having no program in this area? Are you comfortable with that kind of patchwork?

Mr. **Bauer**. Well, I guess this gets to the heart of perhaps the philosophical disagreement that there might be between the Administration and between the authors of the legislation.

We believe the diversified educational system we have, with 16,000 school districts, is a very positive thing; and it allows for a lot of new ideas to be tried, and over a period of time through trial and error for programs to develop nationwide.

We are not pleased historically with the record of Washington trying to mandate programs for 16,000 school districts. It is a very difficult thing to do. And we think local officials are best able to make these decisions.

Mr. **Walgren**. Does it trouble you that in view of the diversity in the school systems and the degree to which school systems from many other States look to one dominant state, like California, for example, that a company like Apple could establish, by gifting to California—establish essentially the accepted educational program and hardware in the area, and then sell that to the rest of the Nation?

Mr. **Bauer**. Well, I guess you are pointing out one of the ways the market system works. I won't say I am 100 percent comfortable with that. But I am more comfortable with it than I am with people here in Washington, including myself, trying to sit down and come up with decisions related to programs and computers, et cetera, that make sense for the entire country.

Mr. **Walgren**. I appreciate that point.

It is true that the forces that would get something going in California would be the same forces that would get something going in Washington; is that not correct?

Mr. **Bauer**. I think some of our California representatives would hope that is true. But I don't think that is always the case.

Mr. Chairman, by the way, I do believe that you will see less and less of a patchwork situation. I mean, I certainly think local communities are coming to this same conclusion that many of your colleagues have come to, and I think we will find over a period of time that more and more of the discretionary money we give through block grants, local educational agencies will in fact be directed toward these areas. But, again, it will take some time for that to happen.

Mr. **Walgren**. Is there any conflict between Secretary Bell, on the one hand, saying that there is a great deficiency in the quality of educational software, and, on the other hand, seeing a Federal program lead to the basic language that is now universally used without any feeling that there was any direct imposition of that language or Federal direction toward that language? It seems to me that is an example where a very essential contribution was made by a federally funded effort that then enabled many other good things to happen.

Isn't there the same potential for that, by Federal investment in software, at this point?

Mr. **Bauer**. Well, we think there is a Federal contribution to be made to the entire area.

I think the thing that I had some problems with is that I am sure inadvertently the quotes that were given of the Secretary this morning really misrepresented the full statement that he made in September of last year. He indicated that there was in fact a problem. But he repeatedly said in his statement that he did not mean his description of what he felt the situation to be around the country to be a call for a massive new Federal spending program. And, in fact, he repeatedly said that the resources we currently have at the Department of Education would be adequate to deal with the problem, if we could convince Congress to perhaps take off some of the strings that are currently connected to what is mistakenly called our discretionary programs.

For example, one program that the Secretary has supposed discretion over really involves only 25 percent of those funds being able to be used in ways that the Secretary thinks important. The Congress has taken the other 75 percent, and although those funds are still in the discretionary account, has placed a great deal of constraints on what the Secretary can do.

We think we have the resources, and we think the Secretary is providing adequate leadership. We would just like a little bit more cooperation on being able to move into these areas without creating a brand-new set of programs to deal with them.

Mr. **Walgren**. And the resources are in the $5 million that you identified as going to that; is that correct?

Mr. **Bauer**. That is one area, the Secretary's discretionary fund. And the overall block grant fund where we can provide leadership in trying to convince school districts to use that substantial amount of money, would be another area.

Mr. **Walgren**. How big is the Secretary's discretionary fund?

Ms. **Cichowski**. The Secretary's discretionary fund is $28 million. But I also wanted to mention there are a variety of other categorical discretionary programs throughout the Department in which resources are available for technology activities, and in fact are being used.

The Department is in the process of preparing a catalogue of projects that we are funding involving the use of microcomputers to improve teaching and learning. I understand it will include some 200 projects supported at tens of millions of dollars.

We would be happy to provide that for the committee as soon as it is released.

Mr. **Walgren**. We would appreciate that.

Mr. Mineta.

Mr. **Mineta**. Thank you, Mr. Chairman.

Mr. Bauer, you speak about the $5 million for this program, or the $12 million for another, or $28 million for this, or tens of millions for others. On page 8, you speak probably about the 12 school systems where you have given some moneys for the demonstration and implementation of educational technology. And yet, you acknowledge that there are some 16,000 school districts in this country.

How do they get some help?

Mr. **Bauer**. Well, as I indicated, 50 percent of the school districts are already utilizing the block grant money that was a major initiative, as you know, of this administration.

Mr. **Mineta**. That is stolen from what other programs?

Mr. **Bauer**. Why do we have to assume it was stolen from anything?

Mr. **Mineta**. It must have been depriving some other existing program. The pie didn't get any bigger. The pie has been getting smaller.

You say we are not going to add any more money, but we will allow those kinds of uses. I know the block grant game. I helped develop the community development block grant of 1974, as a member of the U.S. Conference of Mayors and the National League of Cities. I think block grants are okay for brick and mortar type programs. I don't think block grants, however, when it comes to educational and social service areas, are a realistic approach.

Mr. **Bauer**. Well, obviously again we have a rather significant basic philosophical difference. We do have a commitment to that particular approach. We think the block grant in the Department is working rather well.

I would not describe the decisionmaking process at the State and local level that allocates funds toward one program rather than another as being an exercise in stealing from one program to give to another. Those kinds of decisions are made at any governmental level.

The amount of money that any governmental level has is limited, and one does have to make decisions about priorities. We believe the State and local communities are best able to make those decisions for what they think is most needed in their communities.

Mr. **Mineta**. But aren't there certain national objectives that we want to attain in getting at these goals?

Mr. **Bauer**. Absolutely. We think there is an overall national goal of excellence in education. We believe the Commission on Excellence report and the work that the Secretary has done in the last 1½ years fulfill those leadership goals of identifying what it is that we want to do as a Nation, and hopefully provide some input to State and local communities about what they can do with the money, which, as you know, 90 percent of which comes from the State and local levels rather than here.

Mr. **Mineta**. But as much as you decry Federal mandating of programs, what would be generally the average percentage of Federal dollars in a local school district budget?

Mr. **Bauer**. The number, as you know, is very low. It is, I think, about 8 percent nationwide. I would phrase that a little differently. I am always a little troubled by the idea of Federal versus State dollars and local dollars. They are all, as you know, taxpayer dollars. The only thing we debate is whether the tax money is levied at the State and local level, or levied here in Washington.

We have generally not been very enthusiastic with the idea of Washington levying taxes, sending the money to Washington to pay the salaries of people like myself, and sending what is left back to the State and local level for education. Our approach has been to encourage a national commitment to education, hopefully try to encourage State and local communities to make the necessary financial steps to back up that commitment, and keep the money at the State and local level to be spent as they see fit on programs that they believe is important—that are important—rather than what we think are important.

Mr. **Mineta**. Given the fact that Federal programs, however, are directed at areas that we are interested in attaining, where we are trying to attain a level playing field, it seems to me education is that one area where we all want equal access to opportunities—whether it is a 94-142 program as it relates to special education programs that are provided there, Title I Programs and the Elementary, Secondary Education Act, or a computer literacy program or software availability and development programs.

Don't we somehow have to equalize that across the country rather than let each locality or State dependent on their own wealth be able to reap the benefits of that technology?

Mr. **Bauer**. Well, we think in some respects the block grant program already addresses this in some ways. As you know, the block grant program allows extra funds to be given to those districts that have what is referred to as high cost children. One of the groups of high cost children, for example, would be children from educationally disadvantaged areas, or from educationally disadvantaged income levels. Districts can allocate more—more States can allocate more money toward those districts, where high numbers of those students are.

So, presumably in that area again, those districts that have a lot of those kinds of problems will be getting more block grant funds to develop toward areas like computer education.

Mr. **Mineta**. Are the resources adequate, though, really, to do that, even though the desire may be there? Are the financial resources available to realistically do that?

Mr. **Bauer**. Well, we believe the budget levels we asked for are adequate. And I again would point out that even though every district has basically received these funds, only 50 percent of them are choosing to spend it in this area. That is a decision I think it is very hard for us to second-guess in Washington.

They have looked at their educational system, evaluated what their needs are and have acted accordingly. If they make mistakes, presumably parents through the electoral process will turn out school boards, reform those districts and make other decisions. Otherwise, I assume the decisions they are making adequately reflect the public opinion in that particular school district.

Mr. **Mineta**. I take it you have followed and are aware of the effects of proposition 13 in California.

Mr. **Bauer**. I am, indeed.

Mr. **Mineta**. You think that that is the right direction in which we ought to be approaching education?

Mr. **Bauer**. The citizens of your State have made a decision about the amount of tax money that they want to spend in a variety of areas. I have a very difficult problem philosophically with saying that, because Californians have made that decision, that we should raise taxes for Kentuckians or New York residents in order to help make up the shortfall in California because they have decided they don't want to pay for State taxes.

Mr. MINETA. The Californians did that in maybe 1937 or 1938 to help develop the Tennessee Valley Authority. That was a national issue. Californians were willing to pay to get Tennessee Valley into the 1939 era.

Mr. BAUER. But other States at the same time, I assume, were not saying: "We are going to back out of this; we are not going to make a contribution." And your State, along with some others, have made a decision that they do not want to raise any more State taxes for this particular area.

Mr. MINETA. The State legislature, and including the present incumbent Governor, has bent over backward to try and do everything to help education, despite proposition 13.

Mr. BAUER. Was that a question or a statement?

Mr. MINETA. It is a statement.

Mr. BAUER. I agree.

Mr. MINETA. Even though the voters did pass 13, the State legislature and the Governor have been doing everything since then to try and help bail out the school districts and local governments.

Mr. BAUER. I think they have certainly done everything they possibly can to take what obviously are limited State resources and direct it toward an area which I believe the Governor thinks is a very high priority, which is education.

Mr. MINETA. Let me just touch on Dr. Nicholson's testimony.

Since you have a basic disagreement with the approaches of both of these bills, I am wondering if NSF could provide this committee with a plan on how the current Federal business mix might be able to reach a larger number of school districts with disadvantaged students? I would appreciate it if you could do that for the record.

Dr. NICHOLSON. Sure.

[See p. 77 for response to question.]

Mr. MINETA. Thank you very much.

Mr. WALGREN. Thank you, Mr. Mineta.

Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

One of the things that I am intrigued by, as we have discussed this matter of computer hardware, software, bringing greater utilization of computer technology into the classroom, is how does that impact upon the concern that has been focused upon through the last several years of a high degree of functional illiteracy on the part of American students, the inability to have developed sound concepts of mathematical functions, and to be able to make computations, the impetus to sort of back to basics in American education, which I had looked upon and understood to be a very appropriate emphasis in American education to the extent that the glamor, the sophistication, and so forth, of computers is introduced into the classroom.

Is it going to have any negative offsetting implications for the back to basics movement?

Dr. NICHOLSON. I don't think so. I think it is certainly possible to use computers in sort of foolish ways and there are plenty of examples of that. I think one of the hopes is that it has been possible to use computers in a really more powerful way to help children learn these subjects and one approach to trying to do that is to develop systems that are based on fairly deep understanding of how students do in fact learn and how they learn correctly and how they go about learning in incorrect ways and as a result of research in the cognitive sciences, we are beginning to understand that the kind of models that children develop in their mind, some of which are right and some of which are wrong, we are beginning to understand how that learning process takes place.

We hope in the future we will be able to use computers and have them programmed so the computers, so to speak, understand what the right way to learn and the wrong to learn is and will engage in dialog with the student, called a Socratic method where the computer is Socrates and asks questions and understands when the child is going in the wrong direction and in an interactive way brings them back in the right direction, developing the right mental models of how to do algebra or geometry and the like.

This Socratic method is now coming out which is a sophisticated way to use computers and is at the very other end of the spectrum from the page turning or electronic flashcard that Secretary Bell has referred to.

Mr. **Bateman**. So I need have no fear that, to the extent that we enhance the capability of the American classroom for utilization of computers and computer technology and the educational program that we are undermining the efforts to return to basics and to assure that our students, when they have completed their educational program, do have sound training and competence in mathematical concepts as well as communication skills?

Dr. **Nicholson**. That is the whole idea, to try to use computers as a means of doing that, not as an end in themselves, and that what children need to do is to know how to solve problems, how to learn, be adaptable and change more than they need to know how to put a floppy disk in a computer.

Mr. **Bauer**. Secretary Bell is very concerned about the point that you have raised and he really sees the computer as an instrument to help get back to the basics to make that whole educational need a more challenging type of program. He has spoken many times about the need to avoid fadism, the idea of just having an electronic gadget in the classroom to take up some time while we ignore some of the other important things that need to be done.

I believe he has tried to use his position as Secretary of Education to help explain to local school districts that it is not a substitute for back to basics, but rather something that should go hand in hand with it.

Mr. **Bateman**. That is encouraging. In terms of the relative challenge or problem of education as relating to enhanced computer techniques in the classroom is the larger problem equipment, hardware and software, or is the larger problem classroom instructors who have the capability to use the equipment and to use it wisely, discreetly, were the equipment available—where is the larger immediate challenge?

Dr. **Nicholson**. I think in a sense it is all three areas. The kinds of systems I tried to describe, the so-called Socratic method, which I might mention, in this week's issue of Science magazine, the lead article is by Professor Aarons on this topic where he shows you the whole panorama from the page-turning things to what is possible with this Socratic or expert systems kind of approach that lies in the future. Today, the latter takes a somewhat larger computer than the kinds being talked about in the bills. If you buy a $1,500 PC with 16K, of course you won't be able to do that kind of thing. So, in that sense, the hardware is a problem. The software is a problem because the systems I am describing are just now at the research frontiers where people are developing these things now. So that kind of software is not presently available.

The teachers are important, but as the systems become more sophisticated and better, they are easier to use. One of the buzz words is "user friendly." That means that you or I could sit down and pretty easily use a piece of software without knowing much about how it works, just like we can drive a car without knowing how that works, too. I see progress being made to address all three of those simultaneously.

Mr. **BATEMAN**. I have not had the opportunity to analyze it, but there has been some indication that came to my attention that in the Wirth bill, the definition of computer would exclude terminals and screens, and that that definition may create some limitations upon how much exposure and utilization you can get for the same amount of dollars. Have you had an opportunity to focus on that aspect of it?

Dr. **NICHOLSON**. I honestly haven't studied that part of it very carefully. It was my superficial impression that the definition is perhaps too narrow and could lead to computers that are not that useful.

Mr. **BAUER**. We haven't focused on that point either. We will take another look at it in view of your comment.

Mr. **BATEMAN**. Mr. Chairman, I would like very much for whoever has the requisite skills or expertise to analyze the definitions in order that we have some insights as to whether or not it is a definition which might lead us in a program of this kind to getting less for whatever amount of money is made available than we should be expected to get.

That is all I have at this time, Mr. Chairman.

Mr. **WALGREN**. Thank you, Mr. Bateman.

If you would like to submit any comment on that, it will be included in the record.

Mr. **MINETA**. Mr. Chairman, on that point, does that—if the gentleman from Virginia would yield also on this issue—does that come about because the bill itself talks about a ratio of a machine to 30 students, and the question is with time sharing, can you divide up the number of computers that would be available to that kind of a ratio and if it falls below that, is that where that definition maybe creates the problem?

Mr. **BATEMAN**. That is a part of the concern that I have. If you are going to take one computer per 30 students as an average, what does that get you in terms of meaningful experience and educational opportunity relative to maybe a lesser number of computers, but a larger number of terminals, screens, where the same superior educational opportunity may exist. And my concern immediately becomes: Let's look at this definition and see that if you are going to do anything like this, that we are going to get the most for our money rather than maximizing numbers of computers, but not necessarily have maximized the educational opportunity——

Mr. **Mineta**. But the problem with most of the machines in this room is the fact that once I sit down to start working on that MacIntosh over there, there is no way that you can also get on the machine in terms of time sharing the basic machine. I think that is where the problem is.

Mr. **Bateman**. Well, it may well be a problem and it may be a problem that is not soluble. The one thing I want to make sure is that to the extent the technology is there and the selection of equipment needed to enhance the educational process through computer hardware and software is such that we can maximize the opportunity, the learning capabilities, or experience of the maximum number of students; now whether that dictates——

Mr. **Mineta**. I think the definition is OK. It is just a question of the machine itself is limited in terms of how it gets used.

Mr. **Bateman**. Well, if the definition excludes terminals and screens, but terminals and screens married to certain types of computers are more productive, then we wouldn't want the definition to speak in terms of only a computer excluding the terminals and screens.

Mr. **Mineta**. But that would be the difference of, let's say, what is a MacIntosh $2,000?

From the Audience: $2,495.

Mr. **Mineta**. Including S&H green stamps, I guess. Yet, a machine where you could have terminals going into a main frame may be $30,000, $40,000, or $50,000. I think that is where the difference comes in.

Mr. **Bateman**. I am in no way prepared to say which way it should go. I am prepared to say that we ought to find out which is the better way to go, which is the more cost-effective way to go.

Mr. **Walgren**. Let me—if the gentleman has completed the thought——

Mr. **Bateman**. Yes. I yield back any remaining time I may have had.

Mr. **Walgren**. I would like to ask the representative from the National Science Foundation, you indicate that we already are engaged in institutes for teacher training and I would like to ask if you could submit for the record a statement of the extensiveness of that program, how much money, how many people are contacted by it, and if that can be also broken down into how many of those institutes are related to computer accessibility, that would be helpful information.

And second, you indicate that there is this NSF industry cooperation for science and engineering education using computer programs that started in 1982. If you could give us for the record a description of how that program has progressed, its size, its reach, the number of personnel involved, has it ended—some ability to measure that program's impact on the society as a whole and where it is right now. And that, please for the record, would be helpful.

[The information follows:]

NATIONAL SCIENCE FOUNDATION
SCIENCE AND ENGINEERING EDUCATION DIRECTORATE

Response to Questions on H.R. 3750 and H.R. 4628
from the
Subcommittee on Science, Research and Technology
of the
Committee on Science and Technology
U.S. House of Representatives

QUESTION (from Mr. Mineta): . . . I AM WONDERING IF NSF COULD PROVIDE THIS COMMITTEE WITH A PLAN ON HOW THE CURRENT FEDERAL BUSINESS MIX MIGHT BE ABLE TO REACH A LARGER NUMBER OF SCHOOL DISTRICTS WITH DISADVANTAGED STUDENTS? I WOULD APPRECIATE IT IF YOU COULD DO THAT FOR THE RECORD.

ANSWER: To address your request that NSF provide a plan detailing how the "current federal business mix" might reach a larger number of school districts with disadvantaged students, it is necessary to contrast briefly the missions of the Department of Education and the National Science Foundation with respect to the range of services available, before dealing with the effective application of those services to a special target group like the disadvantaged student.

The Department of Education, throughout its funding history, has provided support for equal access and equal opportunity for students at all levels of education. At the elementary and secondary education level, ED has done this primarily through programs that provide formula grants to State and local educational agencies based on a ratio of student population in the State compared to an aggregate of the same across all States. The Education Consolidation and Improvement Act of 1981 continues the support of its predecessor, the Elementary and Secondary Education Act of 1965, but with an increase in local and State control over how federal funds will be spent at the local level. For example, Chapter 2 of ECIA, otherwise known as the education block grant, consolidated some thirty separate categorical programs many of which had been authorized as separate titles in the Elementary and Secondary Education Act. As was mentioned by the representative of the Department of Education, the State and local educational agencies receiving funds under this program have in recent years elected to use their funds for computer hardware and software, and other computer education-related services.

On the other hand, the National Science Foundation's support in science education has been targeted primarily at providing innovative, high-leverage support for exemplary projects that may be implemented nation-wide. The NSF, unlike the Department of Education, has neither the funding nor the mission to support formula-based assistance to the 16,000 school districts across the Nation, as does the Department of Education. Therefore, within the context of the specific mission of the NSF, the science education program now provides support for model workshops for teachers, high-quality programs for the development of state-of-the art materials for elementary and secondary teachers of science and mathematics, and a variety of complementary informal science and mathematics education programs at museums and other places where informal education opportunities exist.

The NSF has received literally hundreds of proposals from across the country for these types of activities. Within the limitations of our budget, the NSF will support as many of these projects as possible. Virtually every proposal supported by the NSF has some general association with computer education.

Where the Department of Education can boast with certainty a distribution of funds to nearly every one of the 16,000 local educational agencies for the support of education, the NSF offers support for high quality proposals whose products will result in model programs capable of being adopted by many of the 16,000 school districts. The contrast of roles between the Department of Education and the National Science Foundation is particularly important now that each of the State and local educational agencies has the choice of how to spend their education block grant monies. Now more than ever, the NSF has a responsibility to provide model programs of exceptional quality that will give State and local educators additional options from which they can adopt programs consistent with their local choice.

It would be highly impractical and fiscally inefficient for the NSF to adopt a manner of support for disadvantaged students in State and local educational agencies similar to that of the Department of Education. The NSF can most effectively support the concerns of the disadvantaged by continuing in its mission of providing optional programs from which State and local selection can be made. The NSF has explicitly provided reference in its precollege science and mathematics education program announcement that proposals submitted must "reflect an awareness of the needs and potential of the diverse teacher and student population of the nation, such as the gifted and talented, women, minorities, and physically disabled, disadvantaged and students not intending careers in science and engineering." Furthermore, the NSF support for proposals emphasizes the opportunity for cooperative relationships among business and industry, universities, local and State educational agencies, and other non-profit associations. This emphasis is proving productive in the sense that many proposals now being received at the NSF are the product of cooperative efforts of many of these entitites.

QUESTION (from Mr. Walgren): I WOULD LIKE TO ASK THE REPRESENTATIVE FROM THE NATIONAL SCIENCE FOUNDATION, YOU INDICATE THAT WE ALREADY ARE ENGAGED IN INSTITUTES FOR TEACHER TRAINING AND I WOULD LIKE TO ASK IF YOU COULD SUBMIT FOR THE RECORD A STATEMENT OF THE EXTENSIVENESS OF THAT PROGRAM, HOW MUCH MONEY, HOW MANY PEOPLE ARE CONTACTED BY IT, AND IF THAT CAN BE ALSO BROKEN DOWN INTO HOW MANY OF THOSE INSTITUTES ARE RELATED TO COMPUTER ACCESSIBILITY, THAT WOULD BE HELPFUL INFORMATION.

ANSWER: For fiscal year 1983 and to date in fiscal year 1984, the NSF has supported 25 projects in the area of teacher training. These projects total $2,949,575. Seven of the twenty five projects (representing $1,075,615 or 36.5% of the total support) involved 505 participating teachers in a variety of computer instruction activities. The teachers benefiting from this direct participation in computer instruction activities at the NSF teacher training workshops were also encouraged to share the information with their colleagues once they returned to the classroom.

The seven projects are as follows: (as of June, 1984)

Proposal Number	Grantee	Principal Investigator	Funded Amount	Participant
83-16279	N.S.T.A	Marilyn DeWall	$362,327	150-teachers
83-17395	Univ. of Iowa	Robert Yager	321,683	180-teachers
83-19970	Illinois St. Univ.	Carol Thornton	87,918	25-teachers
83-20182	Harvey Mudd Coll.	John B. Rae	98,230	50-teachers
83-20688	Chestnut Hill Coll.	Helen Burke	91,448	30-teachers
84-00357	Hope Coll.	Eugene Jekel	55,119	40-teachers
84-00492	Bradley Univ.	Steve Permuth/ Tony Sastry	58,880	30-teachers
	TOTALS:	7 Projects	$1,075,615	505-participants

Total Workshops Funded in 1983:	21	=	$2,230,680
Total Workshops Funded in 1984:	4	=	718,895
	25	=	$2,949,575

QUESTION (from Mr. Walgren): AND SECONDLY, YOU INDICATE THAT THERE IS THIS NSF INDUSTRY.COOPERATION FOR SCIENCE AND ENGINEERING EDUCATION USING COMPUTER PROGRAMS THAT STARTED IN 1982. IF YOU COULD GIVE US FOR THE RECORD A DESCRIPTION OF HOW THAT PROGRAM HAS PROGRESSED, ITS SIZE, ITS REACH, THE NUMBER OF PERSONNEL INVOLVED, HAS IT ENDED -- SOME ABILITY TO MEASURE THAT PROGRAM'S IMPACT ON THE SOCIETY AS A WHOLE AND WHERE IT IS RIGHT NOW.

ANSWER: The program was operated for one year in 1982. A total of 58 projects were supported using $850,000 in NSF funds and an estimated $850,000 worth of equipment donated by five vendors. In addition, the grantees invested over $500,000 in matching funds of their own. Personnel included at least one principal investigator/project and in some cases additional technical support.

A plan has been developed for an independent third-party evaluation of this program, but the projects do not expire for another 2 years. One-third expire in March 1986 and two-thirds in June 1986. We will have to wait until then to get initial results. The evaluation will address such questions as the value and utility of the outcomes of the individual projects and the program as a whole, taking special account of the unusual feature, namely, the donations.

Mr. **Walgren**. Well, I would like to thank you very much on behalf of the committee. We appreciate your testimony.

At this point, I would like to turn the Chair over to Mr. Mineta and he will carry on and I will return in a short period of time, but to introduce the next panel.

Mr. **Mineta**. Thank you, Mr. Chairman.

We are pleased to have as our next panel Dr. Roy Truby, superintendent of schools, West Virginia, representing the Council of Chief State School Officers; and Dr. Linda Tarr-Whelan, director of government relations, National Education Association.

If both Dr. Truby and Dr. Tarr-Whelan would come forward, we would appreciate it very much. Dr. Truby and Dr. Tarr-Whelan, your full statements will be made a part of the record, and Dr. Truby, if you would go ahead and proceed in your own fashion.

STATEMENT OF DR. ROY TRUBY, SUPERINTENDENT OF SCHOOLS, WEST VIRGINIA, REPRESENTING THE COUNCIL OF CHIEF STATE SCHOOL OFFICERS

Dr. **Truby**. Mr. Chairman, since you have my full statement for the record, I will just really talk from that, and summarize, and hopefully leave some time for questions.

I would like to outline some of the issues as they relate to the use of computers in respective States and to make some specific suggestions with respect to H.R. 3750 and H.R. 4628. We have about—computers now—we estimate 53 percent of all of our schools. In my testimony, I talked about equity and I think when you talk about diversity, you also have to look at the equity factor. The testimony points out that there is a tremendous difference and disparity between schools in affluent areas and schools in poor areas and you may want to look at that.

Our primary problem is software. It is the most significant problem that we deal with. Most of the software that we have really is the drill and practice style. It is estimated that to produce a quality piece of software for one component or for one unit of one course at one grade, it may cost as much as $200,000. And until the software problems are addressed, I don't think that you are going to see a more than modest amount of success with computers in our schools.

If you look at the computer, really it is different than all the televisions, which was supposed to revolutionalize teaching or the overhead projector. They are really tools for the teacher. The computer puts intelligence at the student's desk and actively engages a student, so I don't think that this is going to be a fad.

The computer is going to be with us for a long time. In fact, I think we are going to see the computer more as a tool. We will get away from courses in computer literacy. That is a little bit like having courses in pencils. You don't have courses in pencils. You use pencils. I think eventually we will use the computer much more effectively than we are now. We need to explore the potentials for integrating the computer into other technologies. For example, I suspect that most of the textbooks by the end of this decade will have a little pocket in the back with a computer disk that goes with it.

We need to ask, what can the textbook do better than a computer, and vice versa, and how do we integrate the two together? We need to address what the potentials are for downloading software and using them in an FM radio. How can videotapes be more effectively used in our classroom? There are a lot of very boring lectures that go on in the schools. There may be 8 or 10 people in the United States that are outstanding lecturers on the Civil War period, for example, and maybe the teacher could teach best by being the best listener in a classroom during that sort of thing.

But how can children in the United States, for example, transport themselves into each other's classrooms via videotape? Could children in the United States and Germany get to know each other's culture better by trading videotapes? Or with Russia? We might find that children do a better job of learning to appreciate and understand each other's culture than do governments sometimes. These are the kinds of things that I think we need to do some "blue-skying" with.

The testimony points out that there are a number of projects going on in the respective States. For example, the small State of Rhode Island received an $8 million appropriation for hardware, and their target is a microcomputer for each of 65 students. I mentioned some of the work that Arkansas is doing. They are trying to set up a program to study the effects of the computer in the instructional program and as it relates to achievement.

There are programs in Florida and West Virginia; we have one of the most aggressive computer network systems in the country. When we started ours, we found that there is almost an inverse kind of relationship, in the sense that the students knew more about the computers than the teachers, the teachers are more comfortable with the computer than the principal, and the principal probably knows more than the superintendent, and then you finally get the State superintendent, who can't turn one on. So, there is an ignorance that progresses up the ladder.

I hesitate, Mr. Chairman, to mention defense. I won't get into the B-1 bomber, I promise. I did, at a PTA convention the other day, see a member with a T-shirt that said, "The Pentagon never had a bake sale to buy a bomber," but on a more serious vein, I think a lot of good work is being done in the military Department of Defense with respect to computer technologies. The Department of Defense operates a pretty large educational enterprise, about $13 billion in personnel, $2 billion to $3 billion is being spent for equipment annually. And the Council of Chief State School Officers had a chance to meet with representatives of the military laboratories for the first time last summer and we were pretty impressed with some of the things that they are doing.

Obviously, computer programs for basic and vocational skills are transferable. The same skills are required if you are a civilian auto mechanic as if you are a military auto mechanic.

Mr. Chairman, I would like now to make a few suggestions with respect to the provisions again, not on behalf of West Virginia, but on behalf of the Council of Chief State School Officers, which represents the chief educational leader in the 50 States and various territories. H.R. 3750, we think, could help address the problem of computer equity. We are a little concerned about the 30 to 1 ratio in the sense that there is almost a working assumption that the computer hardware itself is a critical element, and we think that is probably not true. That the critical elements are development of quality software and training programs for the users.

H.R. 3750 does not really take into account the various efforts that are going on in the respective States, doesn't take into account what is happening in Rhode Island or Minnesota or Arkansas or West Virginia.

When we talk about patchwork and disparity, that presents us a problem in West Virginia. We have the most far-reaching court case in the history of the country with respect to equal opportunity. Not equal results, but equal opportunity. The kind of disparity that exists in some States between the affluent and the poorer districts is not acceptable under our Supreme Court ruling, which declared the entire system unconstitutional, and so we have to look at equity. We have to look at equal opportunity and the courses that are available, the curriculum that is available, the equipment that is available. And so we think it will only enhance the patchwork if the Federal Government tries to deal with 16,000 school districts.

It is an administrative nightmare. It is not possible. You can deal much more easily with 50 States and let the States then develop programs and subgrants for the local school systems.

H.R. 3750 gives the Secretary of Education a lot of authority to collect information. We would suggest that this be limited and that the Secretary be required to base all data collection efforts on the recommendations of a national panel of data users.

Finally, Mr. Chairman, we have some comments about H.R. 4628 and the establishment of a semiprivate corporation, which is really developing curriculum for the schools. It is a little bit like setting up a semiprivate corporation with the board of directors appointed by the president to develop textbooks for the schools. The Chief State School Officers are very suspect of this sort of thing and would propose, to the extent that those provisions of H.R. 4628 that address the need for software, that they be combined with H.R. 3750.

In conclusion, we would compliment the sponsors of this legislation and the committee for the legislation. While we are not totally in agreement with it, we think it is an area that needs to be addressed, and with the modifications that I have suggested, the Chief State School Officers would support this type of legislation.

[The prepared statement and biographical sketch of Dr. Truby follow:]

Council of Chief State School Officers

STATEMENT REGARDING H.R. 3750, THE COMPUTER LITERACY ACT
and
H.R. 4628, THE NATIONAL EDUCATIONAL SOFTWARE ACT
Before The
Subcommittee on Science, Research and Technology
of the
Committee on Science and Technology

THE COUNCIL STATEMENT PRESENTED BY

Roy Truby, Superintendent of Schools
State of West Virginia

June 5, 1984

Education
... a sound
investment in
AMERICA

COUNCIL OF CHIEF STATE SCHOOL OFFICERS

JUNE 5, 1984

STATEMENT ON H.R. 3750 AND H.R. 4628

I. Introduction

Mr. Chairman, I am Roy Truby, Superintendent of Schools for the State of West Virginia, and Chairman of the Committee on Legislation of the Council of Chief State School Officers. I am pleased to be here this morning representing the Council. The Council is an independent organization of the state superintendents and commissioners of education in the fifty states, six extra-territorial jurisdictions, and the District of Columbia. Members of the Council are the principal administrative officers for the public school systems of each state, and as such bear a heavy responsibility, along with our colleagues at the local level, for helping to insure that our children are well served by the nation's educational system.

Mr. Chairman, the members of your subcommittee, the Education and Labor Committee, and the principal sponsors and cosponsors of these bills, especially including Mr. Wirth and Mr. Gore, along with Senators Byrd and Lautenberg, are to be commended. Your efforts to address ways in which the federal government can assist the schools in dealing with the rapid and revolutionary impact of new technologies on education are a positive sign that this Congress recognizes an area of real need for the education systems of our country. I see three purposes to my appearance here today, Mr. Chairman:

first, to outline some issues in the area of computers and schools that the Council has recognized through the work of our members;

second, to comment on the specific proposals contained in H.R. 3750 and H.R. 4628 in light of these issues;

third, to examine possible improvements and alternatives to portions of these bills.

The issues I would like to discuss focus particularly on those which are addressed by these bills: equity in computer availability, the relative importance of hardware and other parts of the computer system, efforts now being made to integrate microcomputers into the nation's schools, and the potential and actual role of various parts of the federal government.

II. Computer Literacy is Here--for Some

The number of microcomputers in place in the nation's schools is large, and growing. As of January, 1983, it was reliably estimated that microcomputers could be found in 53% of the nation's schools; the figure continues to rise, especially among secondary schools. Who uses microcomputer equipment, how often, and for what purposes appear to be problem areas for the nation's schools.

Not surprisingly, more computers are found more often in affluent school districts. According to one recent market survey, schools in affluent areas (defined as those in which fewer than five percent of the students are below the poverty line) maintain a student/computer ratio of from 63:1 (rural areas) to 91.4:1 (urban areas). Schools in impoverished areas (defined as those in which more than 25% of the students are below the poverty line) experience a student/computer ratio of from 88.5:1 (rural areas) to 137.4:1 (urban areas). It was estimated (as of 1982) that nearly 30% of schools which have fewer than five percent of their population below the poverty level have at least some microcomputers, while only 12% of schools which have 25% or more of their students below the poverty line have microcomputers.

Within schools, the sorts of exposure young people receive to computers and instruction linked to computers often appears to vary by race and gender. In elementary schools with high concentrations of minority students, microcomputers seem to be used most often for "drill and practice" exercises, while in other schools computer programming instruction is a more frequent use for the equipment. Similarly, females, particularly at the secondary level, often do not participate in advanced computer courses at the same rate as males. Often, the location of a school's limited computer facilities within a mathematics department or other location that is frequently avoided by girls helps assure that girls will not participate equally in computer-based instruction, especially in advanced programming and computer-related courses. Often, the fact that there are far fewer computers available in a school than necessary to give every student adequate opportunities for familiarization means that only those who have the most obvious and immediate interest in computers--generally boys--gain sufficient access to the technology to become truly proficient in its use.

III. Computer Hardware Must Be Viewed as Part of a System

Microcomputers in the classroom are tools for learning. The bills before you focus on using these tools to learn about the tools themselves, that is, about computers. An equally important use for microcomputers is the contribution they can make to the overall school curriculum. As computers become increasingly "user-friendly," detailed training in programming and other somewhat esoteric skills may become relatively less important. Indeed, Richard E. Heckert, vice chairman of E.I. du Pont de Nemours & Co. and the chairman of a committee of the National Academy of Sciences, is quoted in the May 24, 1984 Washington Post as stating, "'Some familiarity with computers is desirable, but as a substitute for the core competencies it's a lousy trade-off.'"

For the microcomputer to be used successfully as a tool in the classroom, it is necessary to recognize that software, hardware, the teacher, the student, the school administrator, and other technologies are all part of an interactive system. No one part of the system is more important or more critical to success than any other part. Work now going on through the Council's State Technology Leadership Project suggests that there are three general categories of "system issues" which must be addressed to integrate microcomputers into schools with genuine long-term success. These issues include: the need for quality software, the need for training to focus on interactive learning through technology, and the need to explore the potential of new technologies within the curriculum.

1. Quality software.

The most significant issue facing state department of education and local school district personnel is ensuring that the software used in instructional programs is of the highest quality possible. It must be much more sophisticated than the common drill-and-practice style that characterizes most software available today. It must be of the type that allows free movement back and forth through the course of study, providing ample opportunities for students to return to areas that are causing them problems.

Production of quality software is a capital-intensive activity. It is estimated that producing a quality piece of software for one unit of one course of study for one grade takes approximately two years and about $200,000.

It must be capable of being used on a variety of hardware. It must be available without legal and/or copyright restrictions which increase costs to the point that only the more affluent school districts can afford it.
And--most importantly--it must be produced with considerable involvement by the ultimate user--the teacher in the classroom--in the beginning stages, including writing, design, and production.

Until these software problems are addressed adequately, the proliferation of computers in the classroom will continue to produce only moderate amounts of success. The computer is a tool, but is it an incomplete, relatively useless tool without quality software.

2. Education for Interactive Learning Technologies

If the computer is to be fully utilized as a tool in the classroom, then it must be viewed in the context of the larger goal of schools. It must be seen as a device that changes as the technology advances, as a device that alters the approach to instruction, and therefore changes a wide range of factors.

including teacher-student relationships and the role of the teacher in the learning process, and as only one of many devices which can have a profound impact on the structure and activities of the typical school classroom.

This new view of the classroom requires preparation of a new type of administrator, one who can play a key role in supporting increasingly well-trained teachers as they attempt to manage the abundance of information generated by diverse instructional technologies. Classroom teachers can easily become overwhelmed by what they must learn about devices that are foreign to them, and by the mountain of new information they must manage if their classroom is to function smoothly. Much of the support teachers need can come from their own training and skills, as these are increased and upgraded. However, providing the complete support system for the technological classroom must be the function of building and system administrators. This means that they, too, must know the tools, what they can do, and what teachers must have if they are to cope. Therefore, massive training and retraining programs for administrators are necessary. Placing computers into situations where this support system does not exist will create havoc, not more effective learning.

3. Exploring the potential of integrating multiple technologies among themselves and into the instructional program

Experts in curriculum design are just now scratching the surface in understanding the variety of uses possible for technology. The most important consideration they must study is the relationship between the computer and the textbook--what does one do better than the other, and how is curriculum designed that makes maximum use of each? A related question is that of determining how curricula and future technological advances can be integrated with one another without requiring extensive redesign of the curriculum with each new technological advance.

In addition, new ways of delivering curriculum must be studied. What are the potentials for downloading software using FM radio? How can interactive videotape be more effectively used in the classroom? Can children in the United States and Germany indeed "transport" themselves into each other's classrooms via videodiscs, providing both groups new ways to learn about different cultures and languages? Answering these questions is imperative if we are to avoid the same pitfalls that dramatic changes have created in the past: new devices that either received little use, and then only as a separate, non-coordinated part of an instruction program; or programs that were used briefly, then stored on the shelf because they were not seen as easy, effective tools in an overall approach to teaching and learning.

States are taking a leading role in addressing these issues, and in assisting local school systems to make the best possible use of new technologies. Many states have activities and programs underway that provide assistance to local school districts in securing computer hardware and software, train teachers and administrators, and establish partnerships with business and industry.

In Rhode Island, the state legislature has allocated $8 million for the purchase of hardware, with the target being a micro for each 65 students. That program will be in place by the beginning of school in September, and teachers will have had opportunities during the summer to take special courses preparing them for integrating the computer into their regular instruction program.

Arkansas' legislature has approved funding for not only placing computers in school districts, but also to set up a program to study the effects of the computer on both the instructional program and the achievement of students.

In Minnesota, the State Board of Education has awarded contracts for the establishment of 10 demonstration sites around the state to improve the delivery of education services through the use of technology. Similar centers are in operation statewide in California, New York, and Texas. California has allocated almost $10 million for teacher training alone.

The Florida legislature has allocated over $16 million for the purchase of hardware and software and for training teachers. An additional $2 million has been earmarked for use by the vocational education program to acquire computer hardware.

Several manufacturers of computer hardware have established partnerships with both state departments of education and local school districts, through which they donate equipment, see to its installation, help train teachers to use the equipment, and send their staff back into the classrooms as they are needed.

These are but a few examples of the efforts states are currently making to assure that the advent of microcomputers and associated technology will be a positive development for the nation's schools.

IV. The Military is a Leader in the Development of Instructional Technology--Let's Apply It to the Public Schools

The issues of technology and instruction are being addressed by the Department of Defense, and the answers can be of immediate assistance to educators across the country. A transfer of instructional knowledge, a "technology transfer," from the military to the education sector is needed.

The Council of Chief State School Officers, through its Ad Hoc Committee on Cooperation with the Department of Defense, has been working with the Department of Defense since 1982 in several areas including instructional technology. The Department of Defense maintains a major education and training function that costs about $13 billion in personnel and $2 to $4 billion in equipment annually.

The Defense Science Board 1982 Summer Study on Training Technology recommended that the Department of Defense accelerate the use of computer-based instructional methods (CAI and CMI) in the military and schools, on the job and in the Reserve Components. The Department of Defense is developing a mechanism to deal with its rapidly expanding and overlapping instructional technologies: TRIADS.

TRIADS is a FY 1983-86 joint service effort to develop a family of software and hardware to support computer-based instruction in a wide variety of military training and education applications. TRIADS will consist of a library of government owned computer-based instructional programs sufficiently flexible to support development, delivery, and management to meet most military instructional requirements. The TRIADS program will also be concerned with demonstration of and specifications for hardware systems capable of executing TRIADS software and, with planning, for institutionalization of joint service computer-based instruction programs. Five military laboratories and centers are directly involved in the development of the TRIADS program.

The criticisms of the public schools and a growing awareness of military instructional resources make the possibility of "transfer" far greater today than in the past. Consider:

- Hundreds of millions of defense dollars are earmarked exclusively for technology development and training.
- Military educational programs serve a segment of the same populations as the public schools.
- Basic skills educational programs with interactive technological instructional systems have been developed by the military.
- Vocational skills can be transferred. Most skills needed by a mechanic are the same, whether he or she works on a civilian or a military vehicle.
- Technology developed by the military at the cost of millions of dollars is available to public educators at little additional cost.
- The Department of Defense has a legislative mandate to facilitate this transfer.

At the 1983 Summer Institute of the Council of Chief State School Officers, the military laboratories and centers for the first time had an opportunity as TRIADS to present a sample of their programs. The Army Research Institute demonstrated programs from its Spatial Data Management System which includes interactive videodisc programs on study skills, learning strategies, test-taking skills and test anxiety management. All of these programs are addressing learning problems that are as common in the public schools as they are in the military. The Barks County Intermediate Unit, Reading, Pennsylvania, is testing some of these programs in its schools at the present time. While the hardware and related costs are assumed by the school district, the developmental costs (approximately $60,000 to $100,000 for one videodisc) have been paid by the military.

In addition, the Army Research Institute demonstrated a hand-held tutor it has developed to teach vocabulary words. The next program to be developed will be in mathematics, a curriculum program which, if there were joint development funds, could be transferable to our schools.

The Navy Personnel Research and Development Center demonstrated its Language Skills Computer Assisted Instruction program. The program is intended to automate literacy instruction in vocabulary and literal comprehension. The program is unusual in that it can be used to enhance the skills in any academic or job content area in any left-to-right alphabetic language. In one part of the program, if the student's native language is not English, he can see a translation of a word into his native language (currently have used Tagalog and Spanish). The program can also use a Votrax voice synthesizer.

During the conference, the Navy demonstrated its Electronic Equipment Maintenance Trainer. This is a two-dimensional trainer/simulator designed to reduce reliance on the use of actual equipment in Navy technical training schools. The repeated faulting of actual equipment can be much more expensive than creating a videodisc, and as equipment modifications are made the videodisc is changed. Two functionally different training programs are currently available: a freeplay simulation program and a flexible instructional strategies program. The freeplay simulation program allows for unstructured practice in equipment operation and maintenance. The second program is designed to support concept level and procedures learning tasks.

The hardware system demonstrated incorporated a microprocessor, floppy disc drives, a videodisc player, a color monitor, a black-and-white monitor and electronically conductive touch panels fitted to the surface of each display monitor for the student to interact with the total system. A portable keyboard/printer was available for the instructor to obtain hard copies of student performance data and for entering new or revised trainer/simulator database information.

The Air Force Human Resources Laboratory demonstrated its Interactive Graphics Simulator. The computer program for the Albany, New York demonstration was hosted on a supercomputer in Colorado. The program is the third in a series to develop, demonstrate, and evaluate the cost/training effectiveness of selected applications of computer-based simulation to relevant Air Force maintenance training. The data collection on this program is expected to be completed next month (July 1984) and the analysis will be completed by September of this year. It is anticipated that the graphics simulator will train procedural knowledge as well as does the actual equipment, and will train trouble-shooting to a higher degree of proficiency.

The Council and other educators have a stake in the future of instructional technology. The over $200 billion education industry in this Nation has a stake in the future of instructional technology. We need better ways to join with the Department of Defense in setting standards, both software and hardware, for instructional technology. Further, we need some way to move this government-owned knowledge and technology into the schools in my state, and all of the schools of our Nation. One such mechanism is the Stevenson-Wydler Technology Innovation Act (P.L. 96-480), which is premised on the notion that technological innovations supported by the federal government should be made available outside the government in rapid fasihion. I submit, Mr. Chairman, that innovations in instructional technology should be made available to our schools just as other innovations are made available to private industry. The Department of Defense has been cooperative and helpful to date in this process, but the widespread adaptation of defense instructional technology for use in the schools will depend on continued congressional support, including financial support.

V. Specific Comments on H.R. 3750 and H.R. 4628

H.R. 3750 and H.R. 4628 are two of several attempts to focus the federal role in assisting the ongoing process of improving the availability and usefulness of computers in the classroom. In light of the issues discussed above, what are the strengths and weaknesses of these bills? Let me discuss them separately, starting with H.R. 3750 (as reported by the Committee on Education and Labor).

- H.R. 3750 could help address the problem of "computer equity"--the distribution and availability of computer equipment, software, and well-trained teachers and administrators. The student/machine ratio of

30:1 posited in the bill is a problem, because it incorporates a working assumption that the computer hardware itself is the critical element in a successful computer-linked educational program, an assumption that is not necessarily accurate.

*H.R. 3750 does not adequately recognize the need to integrate hardware, software, and training in one system--grants for training and a program of software evaluation, while included in the bill, are in separate titles from the basic grant, which is limited only to hardware. In addition, the concern for equity, which seems to motivate the basic grant title of the bill, is not reflected equally in the training and software evaluation titles.

*H.R. 3750 does not take into account efforts already being made at the state level to improve computer-based instruction. For this reason, and because education is fundamentally a state function, we propose that the basic grants be directed to states, which would then sub-grant the funds to local education agencies. Moreover, direct grants from the federal government to local school districts are an administrative nightmare that is, rightly, avoided in other significant federal education programs--in general, grants are made to states, which then sub-grant funds based on approvable local applications.

*H.R. 3750 (sec. 105(d)) gives the U.S. Department of Education blanket authority to collect data and require reports of states. While we favor every sort of accountability for the appropriate and effective expenditure of public funds, we are troubled by the possibility, which we have experienced in other programs, of an unlimited data gathering license being granted to the federal government. The potential data and reporting burden is extensive, and there is no mechanism incorporated in the bill to assure that the data collected would be truly useful or necessary. The Council proposes that the data collection authority of the Secretary be limited, and that the Secretary be required to base all data collection efforts on the recommendations of a national panel of data users and providers.

Our comments about H. R. 4628 are of necessity more general, since the members of the Council do not have much familiarity with the promise of a semi-private corporation to be an effective agent for the continued development of educational software. We are concerned that, as pointed out in testimony before the Education and Labor Committee by the Association of American Publishers, there is a possibility of such a corporation becoming a "back-door" route to an increased degree of federal control of education. All investment decisions would be made by a Presidentially appointed board of directors who would not be accountable to the school systems of this country. Finally, we can determine no way of judging the educational efficacy of corporation investments beyond the open market, which is making judgments about privately developed software now. We propose that, to the extent that H. R. 4628 addresses the need for nationwide efforts to develop effective software, it be combined with the software evaluation functions delineated in H. R. 3750 (Title III), with appropriate attention to the model provided by the previously mentioned Stevenson-Wydler Act.

VI. Conclusion

H.R. 3750 and H.R. 4628 are being considered in a context of rapid developments in the integration of new technologies, especially microcomputers, into the nation's schools. A number of federal policies which have promise for dealing with these developments are in place: Chapter Two of the Education Consolidation and Improvement Act, for which the President has proposed a much-needed $250 million budget increase, is a readily available mechanism for the use of federal funds to purchase computers, training, and software. The technology innovation model incorporated in P.L. 96-480 should be applied more directly to educational innovations, including those made by the Department of Defense.

Mr. Chairman, the Council believes that H.R. 3750 and H.R. 4628 address important national problems. We welcome the prospect of direct federal grants to enhance the efforts states and localities are already making to integrate new technologies into our classrooms. We believe these bills can be greatly improved by adoption of the suggestions we have made; these suggestions are based on our review of what is currently taking place in the school technology environment. The most important single point I might make, Mr. Chairman, is the need to recognize that computer hardware is but one part of a system, and that the successful use of technology requires that we consider and deal with the entire system--teachers and their training, administrators and their training, software, and hardware. The computer is a tool, a means to an end, not an end in itself.

CHIEF STATE SCHOOL OFFICER PROFILE

State: West Virginia
Name: Roy Truby
Title: State Superintendent
Business Address: State Department of Education
1900 Washington Street
Building B, Room 358
Charleston, West Virginia 25305
Business Telephone: (304) 348-2681

Home Address: 398 Mount View Drive
Charleston, West Virginia 25314

Spouse's Name: Sheila Truby

Date Assumed Office: July 1, 1979

Method of Selection: Appointed by State Board of Education

Salary: $57,000 (Effective Date: July 1, 1981)

Chief Deputy: William T. McNeel
Deputy State Superintendent
Building B, Room 360
1900 Washington Street
Charleston, West Virginia 25305
(304) 348-3762

Education History:

B.S., University of Indiana
M.S., University of Indiana
Ed.D., University of Idaho

Employment History:

Most Recent Position: State Superintendent, Charleston, West Virginia

Previous Positions: Superintendent of Public Instruction, Idaho, 1974-1978; Administrative Assistant to Idaho State Superintendent, Administrative Intern, Lewiston, Idaho School District Counselor, Job Corps, Indiana; Teacher, Public Schools Herricks, New Hyde Park, New York

Membership on National Task Forces, Committees, Councils and/or Commissions

Parents in Reading Committee-International Reading Association
National Council Association of Teacher Education

Chief State School Officer's Responsibility for the Following Areas:

- Elementary and Secondary Education
- Vocational Education (Chief State School Officer is the Chief Executive Officer of the Vocational Education Board)

Additional Boards or agencies the chief state school officer reports to e.g. governor, governor's cabinet, vocational education board

Commission on Aging
Education Broadcasting Authority
Board of Public Works
Board of Regents
Teachers' Retirement Board

Mr. **Mineta**. Thank you very much, Dr. Truby.

Dr. Tarr-Whelan.

STATEMENT OF DR. LINDA TARR-WHELAN, DIRECTOR, GOVERNMENT RELATIONS, NATIONAL EDUCATION ASSOCIATION

Ms. **Tarr-Whelan**. Thank you, Mr. Chairman. I would like to summarize my remarks and ask that the full statement be entered into the record.

Mr. **Mineta**. Without objection, so ordered.

Ms. **Tarr-Whelan**. I would like to correct the record. My mother would be pleased by the honorary title, but I do not deserve it, so I am Miss Tarr-Whelan rather than Dr. Tarr-Whelan.

I am the director of Government Relations for the National Education Association. We have 1.7 million members across the United States, who are very interested in the subject matter which is before this committee today. We have testified several times in your oversight hearings, and in the Education and Labor Committee about this. I think it is very appropriate to be dealing with one of the newest challenges before the schools in a room with such impressive evidence of how well we have succeeded in meeting challenges in the past. The astronauts pictured here are graduates of public schools, and as we look to the future of the children who are now in the public schools, I think we must address the problem of the computer and the revolution that is occurring.

Educators welcome the challenge being provided to them in the classrooms. We know the computer itself is merely a tool. To be productive it must be accessible. It must be utilized in a proper environment and for appropriate purposes; and there must be sufficient training, software, and additional resources for those who would use it in the classroom. If we are to be successful in meeting the demands of the decade and beyond, teachers in each school district must be involved directly in the planning, introduction, and use of such new technologies in their schools; to do all of those things we must grapple with the most important question before us, and that is the question of availability and equity.

I will not repeat the kinds of statistics mentioned before the committee except to draw a very important point. Many of the witnesses have talked about the number of computers in the schools. Very few have talked about the numbers of computers in the classrooms and our evidence shows that the vast number of computers being utilized in the schools today are being utilized for administrative purposes, to keep attendance, health records, grades, scheduling, school bus schedules and the like.

The number of computers which are actually available to our teachers to utilize in the classroom for instructional purposes is extraordinarily limited. We have been grappling with this issue for some time, both with the State legislatures and local school boards, as well as with the Congress. I have brought for the committee a survey completed in the spring of 1982 of teachers across the country who are members of our organization, and we represent three-quarters of those classroom teachers, about what is their actual concerns in the classroom of the availability of computers, the support which they have received from school administration, the training which they feel they need in order to utilize this tool successfully. Only 6.2 percent of our teachers were using computers in the classroom whereas 82.9 percent said that they were interested and felt that there was a very important role to be played in all of this.

Secondly, I would like to address the fact that this is the major equity issue for the future. There is a persistent and substantial inequality in the access to new technologies both among schools and among school children. I would refer the committee to a 1983 Johns Hopkins University survey of all schools where they found that the 12,000 wealthiest were four times as likely to have microcomputers as the 12,000 poorest schools. The poorer the school is, the less likely the school is to have any of the new technology.

In addition, I would like to raise the fact that this equity issue is one which is not likely to be addressed without a national commitment. The National Commission on Excellence in Education, which was quoted by previous witnesses, including the representative of the Secretary of Education, clearly set out the fact that there must be national leadership, and so I would like to address the question of what could be the Federal role and what should be the Federal role in this regard. We do believe that the national Government has a national responsibility to deal with the issues of the future and to assist local schools and state resources in providing that.

We have spent considerable time and effort working on an American Defense Education Act, to deal with some of those kinds of issues. The problems out there are very real and the options are somewhat limited. The Federal Government can, in fact, testify before committees that they have all the resources which they need for the problem, which means the problem should no longer be here.

Second, we could deal with purchase options similar to those provided in this legislation, which I will speak to in just a moment.

Second, we could stimulate, through the tax code, donations of equipment. We understand like previous witnesses that this may be considered again in the tax bill which is coming before the Conference Committee, and so my statement does outline some of the problems we see with that approach, or there could be cooperative arrangements between business and government to provide resources for this problem. We would like to note that we are strongly supportive of the Computer Literacy Act of 1984, H.R. 3750, because it provides resources to local communities who wish to participate.

This program is not a program mandated in Washington that every school district must participate in. It has been carefully drawn to be a voluntary program for local school districts who participate with their state in the filing of a computer plan where the state has some limited administrative authority and participation, but the grants will go to those school districts which wish to participate.

Second, we would like to identify the strength of the formula which is included in 3750 which provides that the money should go to the parts of the districts where there is the greatest need first and that there should not be duplication of other programs, regardless of how they have come about by setting a limit on the number of computers which would go first to any particular school. We appreciate the fact that the local education agency should be the deciding factor in terms of how to participate in this program and feel that that is a very substantial strength of this bill.

Second, we believe that title II, which talks in terms of teacher training institutes, is a very important part of this bill and, in fact, follows the model set out by the National Defense Education Act, but, in fact, establishes a much greater national priority on this than what currently exists in the National Science Foundation. Particularly, we would like to applaud the sponsors for the proposals for institutes that would cover individuals serving or preparing to serve in elementary or secondary schools enrolling substantial numbers of culturally, economically, socially or educationally handicapped youth and for programs for children of limited English proficiency.

Likewise, we support title III and appreciate this approach over 4628 for enhancing the development of educational software.

Mr. Chairman and members of this committee, we feel that the Congress is going to be asked to deal with this issue perhaps after the markup in this particular committee, but also to deal with the tax bill question, and I would like to just very quickly outline five tests which should be met for donation programs of computers for them to be substantially an educational program as that which is here before us.

First the computers would have to be utilized for the direct education of students.

Second, there should be geographic and economic diversity in the donation program.

Third, the donation must be treated identically to a direct purchase of equipment with regard to warranties, equipment guarantees, manuals, ancillary materials, and so forth.

Fourth, it is critical that there be sufficient training with each donated computer and, fifth, that there must be provision of sufficient operational and educational software so that the computers can be used in an educationally functional manner.

We look forward, Mr. Chairman, to working with you and members of this committee as we try and work together on a national commitment for preparing the children who are in school today for the type of future which our country needs. We believe that this means there must be support for the purchase of equipment for school districts, there must be support for teacher training and there must be assistance in the evaluation of software and the resources for that software.

We thank you very much for this opportunity to testify before you.

[The prepared statement and biographical sketch of Ms. Tarr-Whelan follows:]

LEGISLATIVE INFORMATION

TESTIMONY
OF THE
NATIONAL EDUCATION ASSOCIATION
ON
COMPUTER TECHNOLOGY IN EDUCATION
BEFORE THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
OF THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
PRESENTED BY
LINDA TARR-WHELAN
DIRECTOR OF GOVERNMENT RELATIONS
JUNE 5, 1984

MARY HATWOOD FUTRELL, President • KEITH GEIGER, Vice President • ROXANNE E. BRADSHAW, Secretary-Treasurer
DON CAMERON, Executive Director
(202) 822-7300

Mr. Chairman and Members of the Subcommittee:

I am Linda Tarr-Whelan, Director of Government Relations for the National Education Association -- ~~our country's largest organization of teachers and others in the field of education.~~ I appreciate this ~~opportunity to testify on behalf of our more than~~ We have 1.7 million members ~~in~~ regard to computer technology in education generally and specifically about two bills which have been reported by the House Committee on Education and Labor: H.R. 3750, the Computer Literacy Act of 1984, and H.R. 4628, the National Educational Software Act.

across the
United
States who
are very interested
in the subject
matter which is
before this Committee
today. ①

Perhaps no one knows better than this Subcommittee that this nation is undergoing a profound transformation -- a revolution really. It is occurring in every sector of our economy and is evident in virtually every aspect of American life. This revolution, with all its opportunities and dangers, is pervasive. Its pace -- unmatched in our history -- has been breathtaking. Rather than slowing down, it appears to be accelerating. And at its center is the computer.

This computer-driven transformation is presenting a major challenge to American education. Increasingly, our schools and colleges are being asked to embark upon a technology related mission: to help our children adapt to this rapidly changing world, to prepare a skilled workforce to meet needs of that world, and to harness the computer itself to better educate our people.

Educators welcome this challenge. But we also know that the computer by itself is merely a tool. Nothing less. Nothing more. To be productive it must be accessible; it must be utilized in a proper environment and for appropriate purposes; and there must be sufficient training, software, and additional resources for those who would use it in the classroom. If we are to ② be successful in meeting the demands of the decade and beyond, teachers in each school district must be involved directly in the planning, introduction, and use of such new technologies in their schools. All those whose professional practice and responsibility will be affected by changing technology must be provided with adequate continuing education. And there must be properly controlled research and the empirical development of all apects of a new technology which is centered on classroom use.

Availability and Equity: The Fundamental Questions

The growth in the number of computers in our nation's schools has been phenomenal. Less than four years ago, the National Center for Education Statistics estimated that there were then some 31,000 microcomputers available for instructional use in public elementary and secondary schools. By the spring of 1982, that number had tripled to 96,000. By the following spring, it had jumped to 217,000. And by last fall, it had risen again -- to 325,000 computers. What is more, this number is expected to double every year for the next five years.

As dramatic and impressive as this growth has been, these figures must be placed in a proper and meaningful context. First, there are over 40 million public school children in this country in 85,000 school buildings. Relatively few students get any computer instruction, let alone an extensive, productive experience. Indeed, our own data shows that as recently as two years ago only 6.2 percent of the nation's teachers were actually using computers in their classrooms. Rather, it appears that in most of our schools where computers are present, this equipment is reserved for administrative uses (attendance, grades, scheduling, budgeting, etc.) or for the classes of only one or two teachers -- generally those who actually teach computer skills. In these schools and others, the lack of computer availability, limited curriculum development, inappropriate or unobtainable software, the absence of teacher training, and the competition for computer time for administrative chores have severely limited the usage of this potentially valuable machinery.

Second, there is a persistent and substantial inequality in the access to new technologies among both schools and school children. Students in economically disadvantaged communities often do not have computers available in their classrooms, because the schools cannot afford them, the parent groups have not raised money for them, and to compound matters, these youngsters do not have them available in their homes, for their families cannot afford them either. On the other hand, students in more affluent areas often have greater numbers of microcomputers in their schools, and, frequently, have computers at home as well. The statistics make the point: according to a 1983 Johns Hopkins University survey of all schools, the 12,000 wealthiest were four times as likely to have microcomputers as were the 12,000 poorest schools. Over 72 percent of the country's most affluent schools now have instructional computers, yet less than 46 percent of the more economically distressed schools have any computer capacity at all. In simple terms, the poorer a school is, the less likely that schools is to have any of this new technology. Even in those less affluent school districts which have managed to obtain computer equipment, there appears to be a significant difference in the quality of those computers, the software they can afford, the training their teachers are provided, and the uses to which this equipment is put.

This disparity manifests itself in the manner in which students are exposed to computers. The present evidence shows that children in economically deprived areas frequently utilize computers, when available, only in a drill-and-practice mode -- something akin to electronic flash cards -- while those students in more affluent communities tend to be exposed to computers in a wider diversity of approaches -- programming, simulation, development of higher level skills.

Taken together, these circumstances widen the gaps between our people -- gaps of affluence, geography, gender, and opportunity. The question of equity of access to school computers is a microcosm of a much larger issue: the necessity to provide access and equity to quality educational experiences for all of our nation's children. We simply cannot allow technology to exacerbate this problem. Rather, it must be used as a direct and positive force to help overcome it.

This is neither merely a local problem nor just a state responsibility. If we are to succeed, it will take the concerted efforts of all of us -- teachers and other educators, parents, students, administrators, public officials, business and labor -- and at all levels of government. But one thing is certain. We will not be succesful unless there is a national commitment, national leadership, and national resources.

The question before this Subcommittee is how best to structure a federal role which will bring the possibilities created by the computer to the classrooms of America.

The Federal Role: Three Approaches

Mr. Chairman, the National Education Association firmly believes that the federal government has a clear and substantial responsibility in helping schools meet the needs created by advancing technology and limited local and state resources. Indeed, the NEA-supported American Defense Education Act -- which has been reported by the House Committee and Education and Labor as H.R. 5609 -- grew out of a recognition of this need: to revitalize local curriculum, to train and retrain teachers, and to provide resources at the local level so that our schools can better meet the challenges of this decade and beyond.

At the same time, we understand and support the call for additional, more targeted initiatives to bring technology -- particularly microcomputers and educational courseware -- directly and immediately into the classroom. It appears to us that there are only three basic approaches to federal support for such an endeavor. These are 1) to provide assistance to states and local school districts for the direct purchase of this equipment and software; 2) to stimulate the donation of such equipment by private industry and individuals; or 3) to promote cooperative arrangements by which schools utilize equipment which is (and remains) in the possession of private industry.

Our preference is clear. The National Education Association believes that the most appropriate and beneficial approach is the provision of direct federal grants to local school districts for planning, curriculum development, teacher training, and acquisition of computer hardware and software. This approach would allow for a sufficiently comprehensive and productive national program -- a program which would place resources, purchase options, and educational decision-making squarely in the hands of the schools themselves.

The Computer Literacy Act of 1984

This Subcommittee now has before it legislation which could help accomplish this: the Computer Literacy Act of 1984 (H.R. 3750). As reported by the House Committee on Education and Labor, this bill addresses four critical areas relating to computers and the schools -- the adequate distribution of and equal access to computer technology; the planning and informational needs of local school districts; teacher training and retraining; and the development of quality educational software.

Title I of H.R. 3750 authorizes a voluntary program for local school districts which file a computer hardware computer procurement program with the state education agency and thereby receive grants for the purchase of computers and related equipment. These grants would be distributed evenly throughout the school districts of the country so that every student would have access to this technology, with priority within each district going to those schools with greatest need. Further, it establishes a cap of one computer per 30 students.

Title II establishes a program of teacher training institutes -- modeled after the training institutes created by the landmark National Defense Education Act -- to be conducted under the auspices of the National Science Foundation through grants and contracts to postsecondary institutions, state education agencies, nonprofit professional science or engineering organizations, science museums, and regional science education centers. These institutes would provide opportunities for advanced study in order for teachers to enhance their abilities, qualifications, and instructional methods in new technologies. There is to be special consideration by the National Science Foundation, moreover, to proposals for institutes for individuals serving or preparing to serve in elementary and secondary schools erolling substantial numbers of culturally, economically, socially, or educationally handicapped youth or in programs for children of limited English language proficiency.

Title III -- incorporating provisions from H.R. 1134, a bill introduced by Representative Thomas J. Downey of New York to create National Centers for Personal Computers in Education, which NEA has supported in the past -- provides for the evaluation of existing computer hardware and software by the National Science Foundation and the National Institute of Education; for the dissemination of information in regard to these evaluations; and for the development of model computer educational courseware. We prefer this approach over that in H.R. 4628 for enhancing the development of educational software.

While we have some concerns over those provisions of H.R. 3750 which relate to the participation of private schools, we believe that the Computer Literacy Act -- with its direct grants to local schools, its acknowledgement of the need for equity as well as excellence, its focus on teacher training and retraining, and its concern for the quality of the technology available -- is a well-reasoned and reasonable approach to the question of how the federal government can assist in bringing high technology into the classroom. We urge this Subcommittee to report it favorably.

The Second Approach: Incentives to Donate

During the 97th Congress, legislation utilizing a different approach to gain more computers for our country's schools passed the

U.S. House of Representatives (as H.R. 5573). If enacted, this measure would have encouraged the donation of computers and other technological equipment to primary and secondary schools by liberalizing the charitable deduction allowable to a corporation for making such contributions. As you will recall, the inspiration for this bill was a proposal by the Apple Computer Company of Cupertino, California, to provide, free of charge, one computer to every elementary, middle, and secondary school in the country in return for more favorable tax treatment of such donations. This legislation has been reintroduced in the 98th Congress as H.R. 701, the Computer Contribution Act, and other legislation utilizing this approach in varying forms is currently pending in both Houses of Congress (including such bills as H.R. 91, H.R. 2417, S. 1194, and S. 1195).

We recognize that this Committee lacks jurisdiction over such legislation. However, in light of the visibility the donation approach has gained, the possibility that it could be an issue in the current conference committee deliberations on the tax package, and the implications of passage of such an approach on the legislation we are discussing today, I believe I would be remiss if I didn't present -- at least for the record -- the National Education Association's position on tax incentives for computer contributions.

As you are aware, several concerns have been raised in regard to the donation approach in the past including: (1) it would leave the selection of computer equipment (or software if included) with the donor rather than with the educational institution; (2) it would be virtually impossible and perhaps inappropriate to attempt to develop a comprehensive federal program within the confines of the Internal

Revenue Code; (3) it could entangle a new federal bureaucracy (the Internal Revenue Service and the Department of the Treasury) in education matters; (4) it is a form of backdoor financing; and (5) it could well set precedents for other -- unacceptable -- types of educational tax credits or deductions such as those for tuition.

The National Education Association has considered these arguments most carefully and while we continue to prefer the direct purchase approach, we recognize the reality of the support such tax treatment legislation has gained in the Congress. Moreover, we can see circumstances under which such donation legislation could be helpful in a limited way -- but only if it is constructed and implemented in such a manner as to assure a beneficial and appropriate educational use in a classroom environment.

To gain NEA support, any such tax treatment legislation would have to meet several tests. First, primary utilization of the donated computer would have to be in the direct education of students. Second, there would have to be proper assurances of geographic and economic diversity in the donation pattern of these computers. Third, the donation most be treated identically to a direct purchase of the same equipment -- that is, all the same guarantees and warranties must apply, the same manuals and ancillary materials provided, the same service agreements honored. Fourth, it is essential that the donor provide sufficient training with each donated computer at no charge to the school or operator to assure that classroom users have access to the knowledge and operating tools necessary to utilize this equipment in the education of elementary and secondary school children. And fifth, such a program must also mandate the provision of sufficient operational and educational software so that these computers can function in a meaningful manner. We believe that H.R. 2417, the Computer Contribution and Teacher Training Act, comes closest to meeting these standards.

Furthermore, should the Congress pass donation-type legislation, it would not eliminate the need for the type of comprehensive approach established under the Computer Literacy Act although it is clear that the 30 pupil ratio would come into play more quickly.

The Third Approach: Cooperative Arrangements

In addition to tax incentives and federal grants as a means to help move technological equipment into the classroom, there remains a final -- albeit less satisfactory -- approach: the increased use of cooperative arrangements. Under this last option, private industry would make its equipment available to educational institutions either at the worksite or, if possible, at school during non-work hours. The federal government could stimulate such cooperation through either tax or non-tax incentives. While such an approach has received more popular discussion and, in fact, has been beneficial in a few instances (particularly at the community college level), it simply does not provide the kind of broad solution to the problem that is required. Limited by the availability of equipment, by distances between school and workplace, and by time constraints on students, teachers, and private industry, it simply is not an effective means to increase the use of computers among school children.

The National Educational Software Act

Finally, Mr. Chairman, I would like to take just a moment to comment on a related piece of legislation pending before this Subcommittee: H.R. 4628. This legislation would establish a National

Educational Software Corporation to promote the development and distribution of high quality, interactive, and educationally useful computer software.

Much of the focus on the technological needs of our schools has concentrated on the availability of computer hardware. But without meaningful and appropriate software, no number of computers will enhance the education of our children. A computer without software is like a motion picture projector lacking film or a book with pages blank. As Ralph Tyler reminds us, the computer is metaphorically a printing press. Yet the invention of printing has not prevented the publication of bad books.

The lack of high quality software has been a major frustration for teachers ever since the microcomputer first started appearing in classrooms. Some of this problem was created simply by the lag between the sophistication of programming and the rapidly improving technological capacity of the hardware. Part was due to economic interests. Manufacturers tended to view schools as a small portion of the total potential computer market. Firms -- many of which were just being established -- were extremely cautious about investing the necessary resources in educational software development in light of what they saw as a very modest educational market. But that situation is rapidly changing. As the number of computers in the schools has increased, so too has the availability of courseware. The marketplace seems to be working. Moreover, some of the companies manufacturing this software are now among the most financially successful corporations in America. The need no longer appears to be that of providing venture capital to software developers, as would be authorized under H.R. 4628.

Rather, it is to accelerate the present competitive trend by allowing market conditions to work by improving purchasing power of schools to buy these programs. The NEA believes that 1) providing means for local school districts to evaluate that software which is available and 2) providing resources to local schools districts to allow them to purchase whatever software best meets their needs is a preferable approach to that authorized by the National Educational Software Act.

Conclusion

Mr. Chairman, the computer has the potential of being an important and powerful educational tool: in academic subjects, word processing, data analysis, planning, individualized instruction. It is also a pervasive influence and presence in American life, with profound implications for our economy, our security, indeed, the fabric of our society. Our nation's schools can and must play a role in utilizing this technology and in preparing our people to face the demands of the years ahead. We are confident that the Congress will fashion a meaningful program of assistance to help our schools and communities meet the challenges and opportunities of the future. We look forward to working with you in that endeavor.

Thank you.

LINDA TARR-WHELAN

Linda Tarr-Whelan is Director of Government Relations for the National Education Association, the 1.7 million membership organization of public school personnel. She joined the NEA staff in July 1980 as Special Assistant to the Executive Director, heading the organization's efforts to achieve ratification of the Equal Rights Amendment, and began her Government Relations duties in December, 1980. She is charged with advancing the NEA's federal legislative agenda as adopted by the Representative Assembly of NEA including collective bargaining rights for public employees, increasing federal funding for public education programs, opposing tuition tax credits, and a number of other issues of professional and personal concern to teachers. This lobby effort takes place in Washington and through Congressional Contact Teams in each Congressional District. Under her supervision NEA also maintains ongoing contacts with Administration agencies which operate various federal programs.

Prior to joining the NEA staff, Tarr-Whelan was a Deputy Assistant to President Carter in the White House Office of Women's Concerns, where she coordinated the Administration's efforts on behalf of ERA and women's issues. From 1977-79 she was Administrative Director of the New York State Department of Labor. From 1969-77 she worked for the American Federation of State, County, and Municipal Employees as Director of Program Development, and as an International Union Area Director.

A native of Springfield, Massachusetts, Tarr-Whelan holds RN and BSN degrees from Johns Hopkins University and an MS from the University of Maryland. She has published articles and served as a consultant to the Ford Foundation and Cornell University on women in the labor force. She has been a member of the faculty of the University of Maryland and Cornell University.

Mr. **Mineta**. Thank you very, very much, Miss Tarr-Whelan. Let me at this point—if I could recess for just a very short time to make a phone call I have got to make. It would probably be just 2 to 3 minutes. I will be right back.

[Recess.]

Mr. **Mineta**. If the subcommittee would reconvene. I appreciate your indulgence.

Dr. Truby, in your testimony you raise the problems of the lack of high quality educational software. Do you feel that private industry provides an adequate level of sophistication in their educational software products and if not, what is the best way to upgrade the quality of educational software? Is that through direct grants, providing venture capital or is there some other approach that might be utilized?

Dr. **Truby**. Certainly the software is getting better than it was, but the hardware is still far advanced for the kind of software that we hope to get in the future. But we believe that through stimulating venture capitalism, that would probably be the best approach in developing the best software, rather than—we are a little concerned about a semi, quasi-governmental entity developing course work really, developing curriculum by a panel which is appointed by the President, regardless of who that President might happen to be.

Mr. **Mineta**. Miss Tarr-Whelan, do I understand that the NEA has created something called the Educational Computer Service, which does evaluation of software programs? I am wondering if you could describe this program and does the evaluation and dissemination responsibilities outlined in H.R. 3750 and 4628 duplicate this effort?

Ms. **Tarr-Whelan**. I will be happy to, Mr. Chairman.

The Educational Computer Service is a joint venture between the NEA, the National Foundation for Improvement of Education, and a private firm, Cordatum, with headquarters in Bethesda, MD. This joint effort evolved because of the need of our own members, who came to us and noted that it was very difficult for them to get quality software for educational purposes; that in many cases they had to, as classroom teachers, individually review large numbers of pieces of software to see if they had classroom utility, and there were no areas that were helping them make those kinds of decisions, so that we have a number of classroom teachers who are participating in evaluating software.

When we first began this in 1980, there were very few people interested in educational software. In fact, a problem was that there was no software being submitted to the Educational Computer Service for evaluation. That is no longer the case. We are seeing a vast number of firms in the educational software area. We have tried to analyze why that is. We believe that part of it has to do with the number of computers now coming into the schools so that there is a market or one which the firms can see in the future.

Second, it may be related to marketplace considerations when the game industry seems to have fallen on hard times. But we are seeing a large number of firms, including some of the most successful in the area, beginning to deal with educational software. We see no conflict between this particular legislation and what we are doing. In fact, I think there is room for everybody in this whole area. We are trying to take out responsibility as a professional association/union to provide some information to our members at their request, but there is certainly plenty of room for other kinds of supported software operations.

Mr. MINETA. Dr. Truby, relative to this program that West Virginia is developing, as I understand it, it is to be installed during the school year 1985–86. I was wondering if you could describe what is contemplated there and, since you did describe it earlier, but is that experience of your network something that is generalizable to other States, and how do you plan on disseminating information on the West Virginia effort?

Dr. TRUBY. You have to remember that West Virginia is perhaps more centralized than most other States in its administration of schools. We perhaps have less local control than you would have in California. So we developed a computerized—a computer system with a curriculum laboratory in a place called Cedar Lakes, which is right outside of Charleston, and that network goes out to the schools and the schools are connected with each other, and they are connected to the laboratory. This is different from the computers that are placed in the hands of the kids. This is a network primarily for teachers and so let me give you then a specific example of how it works.

First of all, you have to understand that when I talk about program equity, we have done more than list courses. In California you say everyone has to take English in the 11th grade, but you list the graduation requirements, and the State stops there. In West Virginia we have developed with teachers and pilot tested what we call learning objectives, learning outcomes, so we have maybe 10 to 20 learning objectives for a sixth grade science class, and those learning objectives are being used throughout the State.

So, for example, a teacher in the system, when the system is fully in place, for a learning objective for sixth grade science, maybe it will punch a button and get 100 teaching objectives. The teacher doesn't have to use them. They could throw them away and write their own. Teachers could feed their own learning objectives into that system. A teacher could push a button and say, "What are the resources available?" The menu would say, "Resource materials printed or visual." So we see this computer network as primarily being designed by and for teachers to enhance the curriculum. It is controversial, because it appears to be a State taking over the curriculum in a sense. We think that it will actually cause more local decisionmaking because it gives you more decisions.

If you look at many, many teaching objectives for a given course, you have more choices, and so it is—I guess it is a very complex system, but that is the best example I could give of how it will be used, we hope, by teachers throughout the system. It is already being used to some extent in our vocational programs, in our vocational centers across the State.

Mr. MINETA. In your resource data bank, does that include what would be considered Federal sources as well or is this mostly just West Virginia?

Dr. **Truby**. It is mostly developed with State dollars. We have had a lot of support for the system from the State legislature, and from the Governor.

Mr. **Mineta**. What about the objectives as far as sources of what is in the data bank?

Dr. **Truby**. The sources, again we have—I don't think this would have worked had we not involved the classroom teachers from the beginning, and they are extensively involved; but first of all, the course objectives are developed with the teachers, and then they are pilot tested by teachers. Then we have, in the pilot test process, we begin to look for resource materials for each of those course objectives. And we look for those things that are plugged in then to the computer network, which will be available to the users. In this case the users are the teachers, not the children. So it is separate and apart from the instructional, the computers that are used directly for instruction with the kids.

Mr. **Mineta**. In your testimony you emphasize the need for massive training and retraining programs for administrators as well as teachers. Does H.R. 3750 address the teacher training needs, and if not, what do you suggest is necessary to meet those needs?

Dr. **Truby**. Well, I think it does, perhaps not fully, but it is a beginning. And it would allow—of course, we think the money should be channeled through the States. That the States and the districts within each State have various—are at various levels as it relates to training personnel. We think the States could be very helpful in providing equity in respect to that. But it is a beginning. And obviously it is not going to take care of all the training needs. There is not enough money in the proposal to do that. But we don't suggest that the Federal Government should take over or should provide all of the training money. That is a shared responsibility between the State, local, and Federal Government.

Mr. **Mineta**. Miss Tarr-Whelan, there is some evidence that some computers are not well used because they are not maintained. Should computer maintenance be a stipulation in order for the local agencies to purchase hardware through this Federal program?

Ms. **Tarr-Whelan**. We have dealt with that issue in those pieces of legislation which are tax donations. We are concerned that school districts which are not able to purchase computers at this time, even if they were given the equipment by some method, might not be able to maintain them. In our standards for tax donations, we have said that that is a very important factor. We have not addressed it in terms of 3750, but it would enhance this particular piece of legislation to be concerned with that issue.

Dr. **Truby**. On that point, when we were bidding for the computer network, the bids were dealing with millions of dollars and one of the stipulations for our bid was that we have people in our vocational schools trained to maintain computers. It was pretty hard to get the companies to do that, by the way. Part of our bid included IBM training program so that some of the employees of the system in our vocational programs would be able to service the computers and that is working fairly well for us.

Mr. **Mineta**. Thank you.

Mr. Bateman.

Mr. **Bateman**. Thank you, Mr. Chairman.

What I have perceived here at the committee this morning is that the software problem may be as significant or even more difficult in the here and now than the hardware problem.

Dr. **Truby**. Oh, yes.

Mr. **Bateman**. If that is the case, do you feel that we are diverting some of the resources and capabilities into hardware that would be better put into the software?

Dr. **Truby**. Well, we think that the software is a more critical problem and perhaps more money ought to be channeled into research for software. But we would like to see some of the ongoing efforts that have already been described for you supported rather than developing another kind of entity to develop software.

Mr. **Bateman**. Well, again, in terms of the software problem, I haven't heard any reference made to where our schools of education are in this and whether or not it should not be one of their functions, not only to enhance the capability of our teachers through institutes for existing teachers as well as for those who are in the process of becoming trained as teachers, whether they should not be given greater emphasis to, in being more effective in preparing teachers for the utilization of computerized educational techniques, No. 1; and, No. 2, isn't this the level where one would expect the most intense effort at developing sound software programs?

I guess generally I am addressing the question: What is the responsibility of our schools of education both in the training of teachers as well as the development of software?

Dr. **Truby**. I think that I have very little confidence in our colleges of education with respect to developing software. I think they can be helpful in training teachers to use software and in working with administrators so that they are more comfortable with the computer, but I don't think the colleges of education can develop software.

Ms. **Tarr-Whelan**. I would like to speak to both issues, your first question as well as your second. I do think that software is a major problem, but the financial difficulty of school districts in purchasing equipment is really severe. You heard a great deal of evidence this morning about the question of chapter 2 and whether school districts were utilizing their resources for computers or not. The poorer school districts are not utilizing their resources from chapter 2 for computers because they desperately need it for other programs which were cut out in previous pulling together of this block grant, which was 29 original programs; that chapter 2 block grant program is now at the Secretary's request for this year still below what those 29 programs were in 1980, not counting inflation or anything else, so that when you talk about what school districts have computers, you are not talking about an equitable situation. You are talking about those who have resources bought first, and those who have parents who have organized bake sales, which is true in many suburban communities for example, they also have computers. But central city schools and poorer rural schools have not had that kind of equipment.

So while I think that the software problem is, in fact, a difficult one, I would hate to leave the impression that it was more difficult than the question of how to get equipment because the financial difficulties of many of the school districts is equity severe.

With regard to the software question and who develops it and who has responsibility, as a professional organization we really see that there is shared responsibility. And we see many, many classroom teachers involved with software firms now in the development of materials. I don't think it was a wholly owned responsibility of anyone that this continued professional development and development of materials and curriculum is, in fact, a responsibility of practicing teachers as well as institutions of teacher education. This is one of the reasons that we have developed an education computer service and are working in this area ourselves along with professionals from universities, not just in teacher education, but with subject matter expertise and why we are interested in supporting the National Science Foundation to do some of the work that is outlined in this bill where there are subject matter experts as well as experts in pedagogical concerns.

Mr. **Bateman**. It seems to me that our schools of education—I don't know where they are, how effective they are generally or which ones are best or which ones perform most poorly, but it would seem to me that just as a matter of the function in our educational system nationwide, schools of education ought to be at the very forefront of all that we are talking about, up to and including, if there is a problem with the development of software programs adaptable to the utilization of computerized techniques in the classroom, where better, where more logically should it be coming from?

Is this a rational reaction on my part or am I totally misconceiving what I would think the role of the schools of education should be?

Ms. **Tarr-Whelan**. I think you are taking them down a path where they haven't been. If you take a look at textbooks as a paralegal, audio-visual materials or other types of tools in the classroom. While the schools of education have participated primarily in the utilization of materials in the same way as Dr. Truby just mentioned, I don't believe that they have been taking a leading role in the development. That has primarily been in the private sector, so we are dealing largely with marketplace influences in this whole question because that is where the textbooks have been written or certainly published, where the audio-visual materials and so forth have been made. So I think you are taking them in a new direction to expect the schools of teacher education to do that. I believe you have a witness later today who might be interested in dealing with that issue.

Mr. **Bateman**. Let me pass on to another area. The question of equity has been raised very frequently, and of course, it is an issue which is always with us, has always been with us.

Is there something, however, in this area of computer hardware, software, and more effective utilization of computerized techniques that makes the equity argument more egregious than it is in all the other educational programs, activities, and funding questions that relate to equal opportunity for our young people and equitable allocation of resources? Is there something here that is different in nature?

Dr. **Truby**. I wouldn't say it is different from textbooks. We consider it just as unequal for one school to have a textbook for every other student, whereas the other school may have two textbooks per student. We would consider that just as unequal as the situation that exists with computers. But because computers are coming in and the first people with the money are going out and buying them, of course, I think you have a more unequitable situation just because computers are newer and the ones that are buying them have them and the ones that can't, don't.

Ms. **Tarr-Whelan**. If we look at the future and where the children that are in school now are going to be in 12 or 15 years, it is quite clear that those who have had some ability to work with computers are going to be in a different place, so we geometrically add to the inequities unless we pay some real attention to this as far as the future is concerned.

Mr. **Bateman**. In terms of the bill and how it would address the equity situation and funding formulas and what have you, looking at page 6, Miss Tarr-Whelan, of your statement, there is a sentence:

> These grants would be distributed evenly throughout the school districts of the country so that every student would have access to this technology with priority within each district going to those schools with greatest need.

Greatest need? Greatest need for what? Greatest need in terms of a system having less computers per capita for the students enrolled?

Ms. **Tarr-Whelan**. I believe that is the way the bill is drawn.

Mr. **Bateman**. Isn't there a danger in that? I can foresee a school superintendent with greater expertise in grantsmanship saying:

> By golly, even though we have relatively more resources if we choose not to use them for computers, we will just file a grant and get those computers, even though we are much better off than another school system that can't get computers except by these grants.

And end up with aggravation of an equity problem that the bill would produce rather than assuage."

Ms. **Tarr-Whelan**. I understand your point. We are concerned in seeing that every child in school has an opportunity to learn with a computer which gets very difficult trying to figure out a formula to do that.

One of the things we liked about this one is that those school districts that have schools with computers would be at the end of the line. This committee in markup may want to deal with other ways to work a formula, and we would be pleased to work with the committee to see if there are more equitable ways to deal with the question that you raised.

Mr. **Bateman**. This member of the committee is making the assumption at this point that we are going forward to marking up a bill and that the bill on its merits is one which best addresses the problem that is there. I would very much like to have input from the educational association and any others as to if we are going to do this. If the taxpayers of America are going to be asked to contribute the resources to make available this enhancement of the individual program, for heavens sakes, what is the best way to reach the equity factor and to see that it goes where it is most needed, not where it is least needed.

Dr. TRUBY. Mr. Chairman, of course we think that the best way to deal with equity is to distribute the money to the States and hold the States accountable for implementing programs that assure equity.

Now, I understand that some of the people will tell you working with the State bureaucracies is just as much of a problem as working with the Federal bureaucracies. But we do have such vast differences in our respective States.

Frankly, it is just crazy for the Federal Government to try to work with 16,000 school districts. It is an administrative nightmare, and it just will not work.

Mr. BATEMAN. I am inclined to that view myself. But let me say there is this measure of concern that comes into my mind. And, of course, this is not the forum, and we don't have the time to pursue it.

But you have indicated that in West Virginia, the State has relatively larger control over the educational system than is true of most States. Yet, you also earlier made the statement that in West Virginia, where you have this large State central control over the system, your courts have held that the way education is supported within the State of West Virginia is unconstitutional.

That gives me some problem.

Dr. TRUBY. That was ironic in the sense that our disparity between the richest and the poorest districts was one-third of the disparity between Texas and California. I believe it was 1.9 percent—some students were having 190 percent more money spent on them than others.

In some States you will find 200, 300 and 400 percent. But our court just said even that was not acceptable. And put us under court order to change it.

Mr. BATEMAN. I want to make clear I am not pointing any fingers at West Virginia. I am using situations of that kind as a part of the problem that we have to wrestle with.

The last area of questions that I have is as to the software and the development of software programs for presenting a curriculum as a part of the learning experience in the classroom.

Does not this get you into the area of great sensitivity and concern historically of: Should the Federal Government, should the Congress, should the U.S. Department of Education have control over or substantial input into the formulation of the curricula, and what is being taught in America's classrooms?

Do you see any problems lurking there?

Dr. TRUBY. I see problems with it.

Ms. TARR-WHELAN. We prefer the approach really that is in title III of 3750, which involves participation in evaluation and a sharing of models and dissemination of ideas, down to the classroom level of successful models. We are, however, concerned and have spent some time with Mr. Gore that he sees a larger problem in the development of capital than we had seen initially, or that we were seeing more recently, to be accurate.

And I am not sure how to meld that. My concern is that we have good educational software and that there is software that is available that can be used in classrooms, not just discussed at meetings, but used with teachers and students.

I am really not an expert on the question of venture capital. He does indeed feel that is a significant problem at this stage.

We do prefer the approach in title III.

Mr. BATEMAN. Thank you.

Thank you, Mr. Chairman.

Mr. MINETA. Thank you very much, Mr. Bateman.

Dr. Truby and Dr. Tarr-Whelan, thank you very, very much for your testimony and help in enlightening the Subcommittee.

At this point, the subcommittee will stand in recess until 1:00 p.m. when Chairman Walgren will be back to chair the Subcommittee. The subcommittee stands in recess.

[Recess.]

Mr. WALGREN [presiding]. Let us convene. I appreciate your patience over the recess.

Mr. WALGREN. We have six more witnesses to go. So the same admonitions, that your full statement will appear as you submit it in writing in the record to be worked with by the committee, along with your verbal testimony, on which I hope you will focus as directly as you can on the points that you feel are singularly important.

The third panel will be made up of Sue Talley, the Education Program Development Manager of Apple Computer; Paul Horwitz from Bolt, Beranek and Newman, Inc., and Harry McQuillen, who is with CBS Educational and Professional Publishing, along with Lois Rice, who is from Control Data Corp., who is not with us, but we hope will join us.

Let's start out in that order. Let me ask you to summarize and outline your testimony.

STATEMENT OF SUE TALLEY, EDUCATION PROGRAM DEVELOPMENT MANAGER, APPLE COMPUTER CORP.

Ms. TALLEY. Thank you, Mr. Chairman. I am very pleased to have this opportunity to testify on behalf of Apple Computer with regard to H.R. 4628 and H.R. 3750.

Apple Computer, as you know, is the pioneer of personal computing in education and the leading supplier of computers to this market. In its short history, Apple has helped define the role of personal computers in education, has educated people to the potential of these machines, and has developed computer systems in direct response to educators' needs.

Since its incorporation in 1977, Apple's own commitment to education has led to the implementation of programs that have had direct impact on the educational community—from the chartering of the Apple Education Foundation, to establishing software publishing relationships with major publishing companies, to the donation of nearly 10,000 computers in California schools.

Apple is dedicated to keeping abreast of the needs of the education market in this emerging computer-oriented society. We also stress the importance of preparing students and educators alike for a technological future.

As Steven P. Jobs, chairman of Apple Computer would have told you if he could have presented this testimony, "To maintain America's technological leadership, we must begin training students at all grade levels in today's computer technology. If we do not, we risk producing a generation of Americans who will be both noncompetitive and nonliterate in the information society that is now evolving."

With this background about the history of our corporate involvement with the uses of computers in education, Apple would like to make the following comments about the bills before this committee.

Apple Computer, as well as most of the leading suppliers of computer hardware to education, has always encouraged the development of high quality courseware by publishers and producers outside of our corporation, many of whom have been active school publishers for years. As mentioned earlier, we have signed development agreements with hundreds of these companies.

These agreements mean that the developer is given access to information about developing software for our hardware which best makes use of the special features of the Apple machines. Often this information is given to developers before the hardware is announced, in order to close the gap between the emergence of new hardware technologies and software using these technologies.

Because of their background in producing and distributing materials to meet curricular objectives in many subject areas, these companies are closer to understanding the needs of the teacher of a particular curriculum. Therefore, it is erroneous to assume that hardware manufacturers are controlling the rights to education software in such a way as to prevent that software from being converted to run on another hardware manufacturer's computer.

The publishers producing the best selling software make every effort to make the materials available for all hardware currently owned by schools in significant numbers: that is, Bank Street Writer and Logo.

Further, by freely sharing information with these developers about the architecture of our hardware, we have encouraged the development of more high quality education courseware. At the present we actively share this information with over a thousand developers, many of whom produce education courseware.

As a result, there are over 2,000 educational courseware packages available for Apple computers and 9 out of 10 of the top selling education packages run on Apples.

The quality and quantity of education courseware has improved tremendously in the last year. There are significant trends to show that the use of computers is shifting to include not only improved drill and practice courseware, but also simulations and productivity tools.

In fact, a recent survey of leading education software publishers, conducted by LINC Resources, shows that 67 percent of the respondents favored a tutorial format, 55 percent simulations, 41 percent game formats, and 41 percent drill and practice materials.

The emphasis, increasingly, is on higher level thinking skills. As the education market becomes more sophisticated in its courseware requirements, and we reach the appropriate point in the learning curve for the education courseware producers, we have the potential for seeing an explosion in the availability of materials for use with computers in the schools.

Finally, we urge caution in establishing criteria for the evaluation and/or selection of education computer courseware. As the introduction of the MacIntosh in January has shown, our technological expectations can be changed overnight by the ever-expanding potential offered by new hardware.

New education software, we believe, will expose educators to an ease of use never before possible without such technologies as the mouse, pull-down menus, and windowing. With the introduction of the IIc, Apple has again shown that technology can be significantly improved while maintaining relative compability.

The graphics capabilities and portability of this new machine offer options to education software developers that never existed before. To establish rigid criteria, in an era of dynamic technological change in the hardware which is economically viable for education, would be a mistake.

There does continue to be a need to encourage development of courseware for low-incidence educational settings. Courseware for a person suffering from a rare disability is certainly needed but rarely profitable, for example. Bilingual courseware for school systems like the Houston independent school district, where 26 different languages are spoken in the homes of their students, is costly to develop and difficult to target to a very specific audience.

Courseware development in these areas does need to be encouraged by the infusion of Federal funds. These thoughts should be weighed in your consideration of H.R. 4268.

With regard to H.R. 3750, Apple has always attempted to establish programs to encourage and enable educators to acquire hardware, train teachers, and disseminate information about reviews of hardware and software. The Kids Can't Wait Program in California and the existing Education Purchase Program reflect Apple's commitment to making hardware accessible for education.

Through the grants offered by the Apple Education Foundation, we encouraged the initial development of education courseware. Now the focus of the foundation grants is on larger projects involving curriculum development and teacher training which exemplify the potential of the microcomputer to enhance learning.

Through Apple Education News, a quarterly newsletter free to educators, and publications like the Personal Guide to Computers in Education, published by Apple, we have attempted to keep educators informed about new advances in hardware and software, as well as innovative methods of implementing computers in education. However, we clearly recognize that these attempts barely scratch the surface in meeting all the needs of educators. Therefore, we support H.R. 3750's attempts to meet these needs.

The current estimate is that by the fall of 1984, over 500,000 computers will be in U.S. schools. While this number increases significantly each year, the ratio of students to computers, on the average, is still far below levels which could be expected to show a significant effect on student learning.

By the fall of 1983, according to a market data retrieval study, 86 percent of all schools had microcomputers. The ratio of computers to students in those schools using microcomputers is 1 to 92.3.

If I include the schools that did not, the current ratio is 1 to 123. Obviously this figure is much greater than the ratio of 1 to 30 proposed in the bill before us today.

The best estimates of the hardware manufacturers would show it will also take us a fair amount of time for the schools with the resources they currently have today to reach that 1 to 30 ratio.

It was mentioned earlier that it would take 4 million computers for us to reach the half hour a day per student. At the estimate of 1 to 30, that is about 10 minutes per day per student to give you some feel.

It is our belief that the education system will continue to need funding support from many different sources for several years, until this ratio reaches acceptable levels. Therefore, we support both the Stark bill and the Wirth/Downey bill as ways of addressing different portions of the acquisition problem.

Mr. Stark has asked us to inform you that he is advising his committee members of a change to his bill which would limit the distribution of the computers to eligible chapter I schools.

We feel this addresses the equity issue that has been raised so many times today. There will also be some other changes made in that bill.

One of the significant ones is that hardware manufacturers will be limited to donating a maximum of 50,000 units of any particular piece of hardware, software or peripherals. It was our experience in California, through the Kids Can't Wait Program, that despite the fact there were no particular controls when hardware could be donated, that schools—that the program was very successful, there was little abuse by hardware manufacturers in terms of dumping obsolete equipment.

Apple donated nearly 10,000 computers—9,751, some number like that.

The fair retail market value of those computers was $20 million. The cost to the State of California in tax revenues was $4 million, and the cost to Apple was $1 million.

Because this bill, H.R. 3750, addresses the general need of education, we see the two bills as being complementary.

I would also like to address Mr. Bateman's questions about the definition of computer hardware contained in this bill, and contained, in fact, in almost all the bills which interestingly enough as far as we can tell probably originally came from the Stark bill.

In terms of screens and VDT's, I think it is important to point out that the trend in the computer industry today is to put intelligence or memory in each of the stations that students or administrators or, in the case of businesses, that managers or others are using, and that the definition itself with a minimum of 16K, we feel, is probably fairly effective in making sure that we are following the current trends.

I would also like to point out we feel there is probably a chicken-and-egg phenomenon that is very difficult to address. Last year, I spent a fair amount of time working in Minnesota as an employee of a consortium in Minnesota, following legislation there that has been referred to several times today.

It was different from any of the bills presented here, because the emphasis was on software development and development of model sites for showing how computers could be used.

Interestingly, the educators reacted in the State to that by saying it is great that you will provide us with software and training and model sites, but we don't have enough money to buy enough hardware to be able to effectively use those tools that you are giving us.

So there is some kind of relationship that needs to be established between amount of hardware, the necessary teacher training, and the necessary amount of software that go hand-in-hand in making for effective use of computers in the schools.

We see teacher training as perhaps the most urgent need. Steve Jobs has called computers "wheels for minds." Computers are tools which can amplify students' and teachers' own inherent intellectual capabilities in ways which have not been possible with any prior technology.

As a hardware manufacturer, we feel responsible for creating machines which make operating the computer a much easier process and for creating materials to teach all users these fundamental operating steps.

However, as a hardware manufacturer, we do not want to dictate the curriculum to be used with computers in school. While we continue to show educators the potential of the computer in education, we feel that teacher training should be done by agencies more familiar with education and teachers than computer companies.

These agencies include local school districts, school district consortia, and other local education agencies as well as the agencies currently listed in the bill. Without this funding for teacher training, computers may never reach their potential for creating change in the education system.

Over the last several years, the definition of computer literacy has been heavily debated among educators. Apple representatives have been told by educators from Alaska to Florida that the introduction of MacIntosh revolutionized their personal views of computer literacy. In some States, however, computer literacy is being narrowly defined by State legislatures as computer programming.

Because Apple computers can be used in nearly all grade levels and subject areas, we are fearful that the title of the bill, Computer Literacy Act of 1984, will be construed to limit the application for which the computers acquired with these funds may be used. A more general title such as Computer Education Act will help to ensure that computers will be viewed by educators as integral to many aspects of the education process.

With the help and vision of the members of this committee and dedicated educators around the country, we hope to reach our vision of computers as wheels for the mind.

Thank you.

[The prepared statement and biographical sketch of Ms. Talley follow:]

U.S. House of Representatives
Committee on Science and Technology
Hearing on H.R. 4628 and H.R. 3750
June 5, 1984

Submitted by:

Sue Talley
Apple Computer, Inc.
Education Program Development Manager

BEST COPY AVAILABLE

Thank you, Mr. Chairman, and Committee members. I am very pleased to have this opportunity to testify on behalf of Apple Computer with regard to H.R. 4628 and H.R. 3750.

Apple Computer, as you know, is the pioneer of personal computing in education and the leading supplier of computers to this market. In its short history, Apple has helped define the role of personal computers in education, has educated people to the potential of these machines, and has developed computer systems in direct response to educators' needs.

Since its incorporation in 1977, Apple's own commitment to education has led to the implementation of programs that have had direct impact on the educational community -- from the chartering of the Apple Education Foundation, to establishing software publishing relationships with major publishing companies, to the donation of nearly 10,000 computers in California schools.

Apple is dedicated to keeping abreast of the needs of the education market in this emerging computer-oriented society. We also stress the importance of preparing students and educators alike for a technological future. As Steven P. Jobs, chairman of Apple Computer would have told you if he could have presented this testimony, "To maintain America's technological leadership, we must begin training students at all grade levels in today's computer technology. If we do not, we risk producing a generation of Americans who will be both non-competitive and non-literate in the information society that is now evolving."

With this background about the history of our corporate involvement with the uses of computers in education, Apple would like to make the following comments about the bills before this committee.

Apple Computer, as well as most of the leading suppliers of computer hardware to education, has always encouraged the development of high quality courseware by publishers and producers outside of our corporation, many of whom have been active school publishers for years. As mentioned earlier, we have signed development agreements with hundreds of these companies. These agreements mean that the developer is given access to information about developing software for our hardware which best makes use of the special features of the Apple machines. Often this information is given to developers before the hardware is announced, in order to close the gap between the emergence of new hardware technologies and software using these technologies. Because of their background in producing and distributing materials to meet curricular objectives in many subject areas, these companies are closer to understanding the needs of the teacher of a particular curriculum. Therefore, it is erroneous to assume that hardware manufacturers are controlling the rights to education software in such a way as to prevent that software from being converted to run on another hardware manufacturer's computer. The publishers producing the best selling software make every effort to make the materials available for all hardware currently owned by schools in significant numbers (e.g. Bank Street Writer and Logo.)

Further, by freely sharing information with these developers about the architecture of our hardware, we have encouraged the development of more high quality education courseware. At the present we actively share this information with over a thousand developers, many of whom produce education courseware. As a result, there are over 2000 educational courseware packages available for

Apple computers and 9 out of 10 of the top selling education packages run on Apples.

The quality and quantity of education courseware has improved tremendously in the last year. There are significant trends to show that the use of computers is shifting to include not only improved drill and practice courseware but also simulations and productivity tools. In fact, a recent survey of leading education software publishers, conducted by LINC Resources, shows that 67% of the respondents favored a tutorial format, 55% simulations, 41% game formats, and 41% drill and practice materials. The emphasis, increasingly, is on higher level thinking skills. As the education market becomes more sophisticated in its courseware requirements, and we reach the appropriate point in the learning curve for the education courseware producers, we have the potential for seeing an explosion in the availability of materials for use with computers in the schools.

Finally, we urge caution in establishing criteria for the evaluation and/or selection of education computer courseware. As the introduction of the Macintosh in January has shown, our technological expectations can be changed overnight by the ever expanding potential offered by new hardware. New education software, we believe, will expose educators to an ease of use never before possible without such technologies as the mouse, pull-down menus, and windowing. With the introduction of the //c, Apple has again shown that technology can be significantly improved while maintaining relative compability. The graphics capabilities and portability of this new machine offer options to education software developers that never existed before. To establish rigid criteria, in an era of dynamic technological change in the hardware which is economically viable for education, would be a mistake.

There does continue to be a need to encourage development of courseware for low-incidence educational settings. Courseware for a person suffering from a rare disability is certainly needed but rarely profitable, for example. Bilingual courseware for school systems like the Houston Independent School District, where 36 different languages are spoken in the homes of their students, is costly to develop and difficult to target to a very specific audience. Courseware development in these areas does need to be encouraged by the infusion of federal funds. These thoughts should be weighed in your consideration of H.R. 4268.

With regard to H.R. 3750, Apple has always attempted to establish programs to encourage and enable educators to acquire hardware, train teachers, and disseminate information about reviews of hardware and software. The Kids Can't Wait program in California and the existing Education Purchase program reflect Apple's commitment to making hardware accessible for education. Through the grants offered by the Apple Education Foundation, we encouraged the initial development of education courseware. Now the focus of the Foundation grants is on larger projects involving curriculum development and teacher training which exemplify the potential of the microcomputer to enhance learning. Through Apple Education News , a quarterly newsletter free to educators, and publications like the Personal Guide to Computers in Education , published by Apple, we have attempted to keep educators informed about new advances in hardware and software, as well as innovative methods of implementing computers in education. However, we clearly recognize that these attempts barely scratch the surface in meeting all the needs of educators. Therefore, we support H.R. 3750's attempts to meet these needs.

The current estimate is that by the fall of 1984, over 500,000 computers will be in U.S. schools. While this number increases significantly each year, the ratio of students to computers, on the average, is still far below levels which could be expected to show a significant effect on student learning. By the fall of 1983, according to a Market Data Retrieval study, 86% of all schools had microcomputers. The ratio of computers to students in those schools using microcomputers is 1 to 92.3. Obviously, this figure is much greater than the ratio of 1 to 30 proposed in the bill before us today.

It is our belief that the education system will continue to need funding support from many different sources for several years, until this ratio reaches acceptable levels. Therefore, we support both the Stark bill and the Wirth/Downey bill as ways of addressing different portions of the acquisition problem. Mr. Stark has asked us to inform you that he is advising his committee members of a change to his bill which would limit the distribution of the computers to eligible Chapter I schools. Because this bill, H.R. 3750, addresses the general needs of education, we see the bills as complementary.

Teacher training is perhaps the most urgent need we see. Steve Jobs has called computers "wheels for minds." Computers are tools which can amplify students' and teachers' own inherent intellectual capabilities in ways which have not been possible with any prior technology. As a hardware manufacturer we feel responsible for creating machines which make operating the computer a much easier process and for creating materials to teach all users these fundamental operating steps. However, as a hardware manufacturer we do not want to dictate the curriculum to be used with computers in school. While we continue to show educators the potential of the computer in education, we feel that teacher training should be done by agencies more familiar with education and teachers than computer companies. These agencies include local school districts, school district consortia, and other local education agencies as well as the agencies currently listed in the bill. Without this funding for teacher training, computers may never reach their potential for creating change in the education system.

Over the last several years, the definition of "computer literacy" has been heavily debated among educators. Apple representatives have been told by educators from Alaska to Florida that the introduction of Macintosh revolutionized their personal views of computer literacy. In some states, however, computer literacy is being narrowly defined by state legislatures as computer programming. Because Apple computers can be used in nearly all grade levels and subject areas, we are fearful that the title of the bill, Computer Literacy Act of 1984, will be construed to limit the application for which the computers acquired with these funds may be used. A more general title such as Computer Education Act will help to ensure that computers will be viewed by educators as integral to many aspects of the education process.

We believe that people have a greater capacity for intellectual and social development than is ordinarily realized, and that computer-based tools can open doors into higher levels of functioning for our children and students. Computers can, if used appropriately and with the right software, enhance learning in any area. Microcomputers can be used to help students structure information, ideas and relationships which are critical to understanding the important ideas in language, history, mathematics, science, art, and music. Apple will continue to strive for excellence in creating computers that are appropriate for education. With the help and vision of the members of this committee, and dedicated educators around the country, we hope to reach our vision of computers as "wheels for the mind."

Sue Bark Talley
Apple Computer, Inc.
20525 Mariani, MS 18-C
Cupertino, CA 95014
(408) 973-2858

SUMMARY OF WORK EXPERIENCE: Currently employed as Education Marketing Manager for Elementary-Secondary Education at Apple Computer. Responsibilities include editing the quarterly newsletter, *Apple Education News*, and providing direction for the handling of products at education oriented trade shows. Serve as a resource for the rest of the company in explaining the education market for new products. Also involved in current promotions, such as **Apple Computer Clubs**, and developing new promotions.

Previously had seven years of direct experience with computers in education while employed by TIES, a regional consortium in Minnesota. Also used computers with students as an English teacher and as a teaching assistant in college. Have been responsible for providing computer services to sixty school districts served by over 3000 microcomputers. In the instructional area these services included consulting, teacher in-service, and courseware development. For the administrative area these services included the development of administrative packages and in-service for administrators on productivity tools. Staff included, on the average, thirty people plus contractors and teachers hired for special projects.

EDUCATION WORK EXPERIENCE:

Apple Computer, Inc., Cupertino, CA. 11/ 83 to present.
Elementary-Secondary Education Marketing Manager.

Minnesota School Districts Data Processing Joint Board (TIES), St. Paul, MN.
7/77 - 11/83. Manager, Microcomputer Systems.

Park Senior High School, Cottage Grove, MN 8/7 - 6/77.
English teacher.

EDUCATION:

University of Minnesota	Graduate work in computer science/ education
Macalester College, St. Paul, MN	B.A. English, Psychology, Education

PROFESSIONAL ACTIVITIES:

Member of International Association for Educational Data Systems Board -- 1983-6.

Member of International Council for Computers in Education Board -- 1983-4.

Member of AFIPS Secondary Education Project Steering Committee.

Advisor for Harcourt, Brace, Jovanovich on Computer Literacy curriculum.

Advisor for Education Testing Service Teacher Training Project -- 1983.

Consultant for Special Project, Northwest Regional Education Laboratory -- 1983.

President of Minnesota AEDS -- 1982-3.

Participant in California Software Evaluation Forum -- 1983.

Steering Committee for the Elementary, Secondary, Junior College Special Interest Group of ADCIS.

Member of Executive Committee for Minnesota Association for Supervision and Curriculum Development -- 1982.

Co-Chairman of the Program Committee for the AEDS Convention -- 1981.

WRITTEN MATERIAL:

"State of the Computer Art: Management and Instruction." The School Administrator. April 1981. pg. 8, 37.

The Use of a Computer to Help Teach the School Curriculum. Booklet produced as a result of a cooperative effort by MASCD, MASA, and the Minnesota Department of Education.

Planning for Educational Technology. Part of a team which produced this booklet for the Minnesota Department of Education.

"Selection and Acquisition of Administrative Microcomputer Software." AEDS Journal. December 1983.

"TIES -- A Regional Computing Center." To be published in a new book entitled Some Application for Microcomputers.

PRESENTATIONS AND WORKSHOPS:

April, 1978	Great Falls, Montana	
January, 1980	Parkersburg, West Virginia	
April, 1980	Flagstaff, Arizona	
July, 1980	Miami, Florida	
November, 1980	Pasco County, Florida	
July, 1981	Washington, D.C.	NASE Seminar
December, 1981	Boston, Massachusetts	NASE Seminar
June, 1982	Vancouver, B.C.	ADCIS
	High Point, North Carolina	
	Indianapolis, Indiana	
July, 1982	Tucson, Arizona	NASE Seminar
November, 1982	School City of Mishawaka, Indiana	
March, 1983	Arizona State University	
July, 1983	St. Petersburg, Florida	NASE Seminar
September, 1983	Indianapolis, Indiana	
October, 1983	San Jose, California	CUE Conference
February, 1984	Orlando, Florida	Florida Computing Conference

Mr. **Walgren.** Thank you very much.
Dr. Horwitz.

STATEMENT OF DR. PAUL HORWITZ, BOLT, BERANEK & NEWMAN, INC.

Dr. **Horwitz.** Thank you. My name is Paul Horwitz. I work at Bolt, Beranek & Newman, Inc., which is, among other things, a software R&D firm located in Cambridge, MA.

I am going to do what every other witness has done in the last several hours—dispense with my written testimony, and speak to you extemporaneously, and attempt to highlight the important points of my written testimony.

Hopefully, what I say will gain in spontaneity what it may lose in literateness.

I have been very gratified at the fact that Bolt, Beranek and Newman have been mentioned either directly or indirectly three different times in this testimony. We are developers of the LOGO language, contrary to public opinion.

I have to correct the record here. It was not developed under National Science Foundation funds. It was developed under Office of Naval Research funds. Further development took place under NSF, however.

We also have been cited as developers of the QUILL program, which was recently sponsored by the Department of Education, and has been extraordinarily successful in revolutionizing the way kids are learning to write in the schools at every grade level from fourth grade through high school.

I am going to make one point that may not be agreed—may not be universally agreed with by the people in this room. I think, first of all, we can all agree we probably share in this room a sentiment that those magic little boxes here have some potential for education, that somehow teaching can be improved with those little boxes.

I am not certain how many people would agree with what I am about to say, but I believe very strongly that we don't yet know how to teach with those little boxes. Or certainly we don't know very much about how to teach with them.

I think that is crucial to understand in approaching these two bills. I want to talk a little bit more about that, and then I will dive down into specifics of the bills that I like and don't like.

We are very much at the beginning of a revolution here. We have said that many times, but I think we ought to stop and think a little bit about what that really means.

In my written testimony, I make the analogy with books, and I talk about it as though we were now trying to discuss moveable type has recently been invented, and we are trying to discuss what is going to happen with books in the schools.

We are very much at that stage with computers. Much of what we have attempted to do with computers is to replicate what we already know.

We put on computers books. We have automated books. We have automated the blackboard. We have automated the film strip. We have film strips now which will give you a simulation of the Milliken oil drop experiment on a computer, rather than film strip.

I submit to you that none of those are probably going to be the final step in this evolution. I submit to you further that it is not the people are stupid that they do these things, nor the fact that there hasn't been enough money, I believe.

It is the fact that it takes time. It takes time and research, both in computer science and in cognitive psychology, and a lot of other things, before one can begin to grasp what the potential really is of that magic technology.

That support has got to come from the Federal Government. I do not believe that market forces are sufficient to ensure the appropriate amount of risk capital, if you will, to do the very careful research that needs to be done before we can really figure out what is to be done with the computer in the classroom.

It is a national priority, and it is something which I believe the Federal Government has a very strong role to play in furthering.

Given that, how did I approach these two bills? Well, I approached them with great anticipation. I am sorry to tell you I cannot support them wholeheartedly. However, I do support them in part.

Let's start with H.R. 3750. It addresses some very important needs. The need for equity in the schools is certainly one which no one in this room would argue against, and I think it addresses it, in some ways admirably.

I believe, however, title I is seriously flawed in dealing only with hardware acquisition. That goes back to the business of thinking that the computer is all it takes. That if I put the little box in the classroom, magic is going to happen and kids are going to learn.

I can imagine people in 1450 saying "what we need is a book in every classroom", without regard to what that book says.

What the book says in this instance is the software, and it is more than just software. It is the software and it is the activities that go around that computer, it is the changes that computer makes in the classroom that really make the difference.

So I have called that, those activities, curriculum in my testimony, and I am now sorry I did, because I get the impression that that may convey the wrong impression. That may convey the impression that I am talking about content.

I am really not. I am talking about activities surrounding the computer, hardware and software, that make it work, and that make it work when you have one in a classroom or four, or one for every kid.

The activities are quite different in those different situations.

I don't believe that a bill which addresses only one part of that tripartite need—software, activities, and hardware—can really succeed.

Turning to titles II and III, I am going to say something which is going to sound self-serving here, but so be it. I believe the word nonprofit in those titles is misplaced. I don't believe that it serves an important public purpose to exclude from consideration under those titles, particularly under title III, the developers of LOGO, the developers of SmallTalk.

It was mentioned earlier that the Macintosh has a mouse and pull-down menus and windows and the like. That was developed at Xerox PARC for educational purposes.

Xerox PARC is a profit-making institution. You have excluded them in this bill. I don't believe that serves an identifiable public purpose.

Also, in title III you have a paragraph which biases the bill, I believe, in favor of federally-owned institutions, particular institutions mentioned, but the paragraph is not exclusive—NIE regional laboratories.

I don't believe that that langage has any part in a bill of this kind. I believe it is degrading to the institutions to feel that they need to be protected by special statute against competition, and I believe that you get the best work by funding the best research regardless of where it may come from.

Turning now to H.R. 4628, the Gore bill. I am afraid I have to come down on the conclusion that that bill addresses the wrong problem. I have said earlier that I don't believe that the admitted lack of quality in much of the current educational software, not all by any means, is primarily a lack of venture capital.

I believe it is primarily a lack of expertise. I believe we are not yet mature enough collectively to have figured out all the clever things that can be done with computers in the classroom.

I don't believe throwing money at it in that particular way is the right approach to speed things up.

Furthermore, I am not certain that I understand how a national software corporation, along the lines envisaged in the bill, would differ markedly from existing institutions, both public and private. It would be inbetween.

I know the parallel very well with the MTDC mentioned by Representative Gore. I come from Massachusetts and was involved in the early stages of that legislation.

But I am not certain that the software problem is the right one for that kind of approach. So I really do not support passage of that bill.

Thank you very much.

[The statement and biographical sketch of Dr. Horwitz follow:]

Testimony of Paul Horwitz

Bolt Beranek and Newman. Inc

Delivered Before the Subcommittee on
Science Research and Technology
of the Committee on Science and Technology
US House of Representatives

June 5. 1984

Introduction

Good morning my name is Paul Horwitz and I am involved in research and the design and development of educational software at Bolt Beranek and Newman Inc in Cambridge Massachusetts I would like to thank the Chairman and members of the Subcommittee for giving me this opportunity to testify on H.R. 3750 and H.R. 4628

In the interest of time I am going to give you a brief summary of my views on these two bills, after which I will try to describe for you the reasoning and judgments which have led to those views With respect to H.R. 3750. the Computer Literacy Act, I believe

o That the language in Sections 201(a) and 302(b) is unduly restrictive particularly in excluding profit making institutions from participating in the programs described in these sections In particular, Section 302(b) would have the effect of excluding a major part of the Nation s expertise in educational uses of computer technology including the institutions responsible for the development of the LOGO and

BEST COPY AVAILABLE

SmallTalk computer languages.

- That Title I should be broadened to include provision for the purchase of software for use by the recipient schools. The exclusion of software is likely to have catastrophic effects. Paradoxically, it will denigrate the value of software in the eyes of school officials, while making available to them computing equipment which, devoid of software and even more importantly devoid of *curriculum*, will prove essentially useless. Such a shortsighted policy is likely to result in a collective "loss of faith" in the value of computers to education. It will also encourage an increase in software piracy--a problem which is already very serious.

- Some of the language in Section 302(a), as well as in the accompanying committee report has the effect of producing a strong bias in favor of certain Federally owned research institutions. Such a bias is discriminatory and counter-productive and should be eliminated.

- Finally, I question the value of a bill directed at teaching students and teachers how to *use* computers, rather than how to *learn* with them. I shall return to this theme below.

With respect to H.R. 4628, The National Educational Software Act, I applaud its motives, but have some reservations about it, as well.

- I believe that H.R. 4628 is attempting to solve the wrong problem. To the best of my knowledge, there is no hard evidence for a failure of the venture capital market as the cause of any perceived inadequacy in educational computer software. Until and unless convincing evidence is adduced for such a failure, government action on the scale envisaged would seem at best premature.

- Even if one could show that operative market forces were insufficient to produce a desirable level of venture funding, the proposed solution would not rank high among my choices. It is by now means a foregone conclusion that a governmental entity such as the proposed National

> Educational Software Corporation will succeed in a producing high-quality product where other public and private sector institutions have failed.

Having gotten all that off my chest, let me now begin at the beginning and introduce myself and my employer. Let me also hasten to add that I am not here representing Bolt Beranek and Newman in any official capacity. The views expressed are entirely my own, and no attempt has been made to put a "BBN stamp" on them. Nonetheless, my views clearly reflect my background, and since this is intimately tied up with my job, an introduction to BBN is definitely in order.

Bolt Beranek and Newman, Inc. is a $100 million a year company whose activities span the range from architectural acoustics consulting to designing and building computer networks. We are perhaps best known to the outside world as the developers of the ARPANET, a pioneering computer network developed in the late 1960's. We also are credited with the first public demonstration of a time-sharing computer system. It is interesting in the present context to note that the first published research using this system was a psychological experiment involved with learning theory. (This may well have been the first psychological experiment ever performed that was completely controlled by a computer.) BBN also pioneered the application of artificial intelligence techniques to computer-assisted instruction, creating systems capable of engaging a student in meaningful discourse, forming models of the student's state of knowledge, and offering helpful advice and guidance.

Perhaps the most influential product of BBN educational technology has been the design and implementation of the LOGO computer language, a sophisticated yet easy to learn language designed to introduce children to concepts of programming and more general problem solving skills. Although much of the later work with LOGO took place at MIT under the direction of Seymour Papert (whose influential book *Mindstorms* has made LOGO a household word in educational circles) the initial design and implementation of the language was done at Bolt Beranek and Newman in 1966, under the sponsorship of the Office of Naval Research.

Research and development in educational technology at BBN has grown since those early years. Today the Educational Research Group numbers well over a dozen Ph.D. level researchers from a variety of disciplines including cognitive psychology, computer science and physics.

I myself am a physicist with experience in teaching and research, both in universities and industry. In 1975, I was awarded a Congressional Fellowship by the American Physical Society and spent a very pleasant year in the office of Senator Edward Kennedy, working on a number of Federal Research and Development policy initiatives. Following this, I spent several years at MIT's Center for Policy Alternatives, studying and writing about technological innovation and the effect of Federal government policies on it. I have been at Bolt Beranek and Newman for about 5 years and my primary interest is in the design and development of computer-based systems for representing and teaching science and mathematics.

General overview

After reading carefully the two bills that are the subject of today's hearing, I was surprised that I was not more favorably impressed by them. Frankly, I had expected to like them more than, on sober reflection, I did. I have tried to analyze the reason for my unexpected discontent, and I think I can summarize it in this way. Each bill, it seems to me, has grasped only a part of the overall problem. In each case it is an important part to be sure, but too narrow a focus on a part may well impede efforts to deal with the rest. H.R. 3750 by concentrating on "computer literacy", and H.R. 4628 by concentrating on the funding mechanisms for educational software, have each lost sight of a crucial fact: *we don't know very much about how to use computers to teach*. That is why there is so little good software out there--not just because the profit motive is insufficient, but because we don't yet know how to produce good software. That is why teacher training is so hard--not because it is so hard to learn how to *run* a computer, but because it is hard to learn how to _teach_ with one. That is why we don't just need hardware in the schools--we need software and, even more important, we need _curriculum_. We need computer-based _activities_ that work in a classroom.

A historical tale

Let me try to illustrate this point by an analogy. With a certain amount of poetic license and apologies to the more historically-minded among you, let us go back to the year 1450. Gutenberg invented movable type about a decade and a half ago and the invention is beginning to be disseminated throughout Europe. We are met to discuss the implications for education of this new technology. There are various schools of thought.

Some feel, for example, that books are a passing fad, that it makes very little difference if books become cheap because no one knows how to read and even if they did, very little exists that is worth reading. The sentiment is summed up by the oft-heard statement "Books are here today and likely to be gone tomorrow".

Others, equally vociferously, take the opposite view. Not only are books already here today, but they will be here in ever increasing numbers tomorrow, not to mention next week. "Our children", says this group, "are going to grow up in a 'book age'. Unless we do something right now they won't be able to get jobs in the high-tech, book-ridden world of tomorrow."

"Literacy" courses spring up all over the place. "A book in every classroom" is the cry. Then some of the more farsighted educators come to realize that the major obstacle to introducing books into the schools is the scarcity of appropriate "software". They realize that it is not enough to reproduce the classical works of the Latin and Greek authors that have been so studiously copied and maintained by legions of monks. What is needed is brand new books: books that teach children how to read, books that teach about books.

The thought that books can be used to teach other things--Latin, Greek, perhaps even practical arts like falconry, or alchemy--comes a bit later. Eventually, the society as a whole learns to accept books wholeheartedly into the curriculum, and wakes up to discover that the old Socratic tradition of oral, one-on-one education is gone forever.

Our time machine shifts again. It is 1960. In the wake of Sputnik, America is turning to a new and exciting technology to improve the education of its children. Television holds the answer to the Nation's educational needs. Video equipment of all kinds is rushed to the schools, used briefly and stored away. Much of that equipment exists today still in its original packing crates.

The example is clear. If the educational computer is not to go the route of television, something is going to have to be done to teach us how to use it wisely and well.

The Federal role

An obvious question comes up at this point. Assuming, for the sake of argument, that there is general agreement that the computer has a vast, and largely untapped, potential for teaching, why can't the market place be counted on to produce the appropriate combinations of hardware and software, in response to an evident and growing demand? The question is not a simple one and the answer to it is not simple either. (I used to make my living debating this kind of question!) It all boils down, though, to the point made above. If we already knew what to do with computers in the classroom, I believe the role of the Federal government might well be relegated to dealing with other important issues, such as those addressed in Titles 1 and 2 of H.R 3750. But the fact is that we do not have all the answers, and the only mechanism available to us in this circumstance is Federal support for the necessary research, early prototyping and large scale evaluation. Whether the Federal government need be directly involved in the actual production of finished product is one of those endless debates that ultimately rest on value judgments. As I have indicated above, I strongly believe, based on considerable study and thought, that the such a role is best left to the private sector

Recommendations

One of the things I learned in my little stint in the Senate was never to leave a memo without a "bottom line". I believe the same rule applies here. I have tried to tell you what I don't like about the two bills before us. I have tried to tell you why, and to give you enough information about my background and reasoning processes for you to form your own judgment as to how much attention to give to my remarks. Here, then, are my recommendations for H.R. 3750.

- Get rid of the offending word "nonprofit" in Sections 201(a) and 302(a). No reasonable public policy goal is furthered by excluding a major portion of the private sector expertise that would otherwise be available to be tapped by NIE and NSF. In many cases, there is very little real difference between profit-making and non-profit institutions, except that one pays taxes and has stockholders, the other does not. If the concern in Section 302(a) is to avoid the displacement of private funds, language can easily be inserted requiring that the government share with the participating private sector institution whatever royalties or other remuneration may accrue from the promotion and sale of the educational product(s) produced. This is what was done with LOGO and Sesame Street, to name two well known examples. BBN and The Network, in fact, have recently concluded a very successful project, funded by the Center for Libraries and Education Improvement of the Department of Education, which has resulted in a computer-based writing tool, called QUILL, that has been licensed to D.C. Heath for marketing, distribution and sale. The royalty stream is shared among the participants under a mutually satisfactory arrangement, and everybody wins--most especially the growing group of enthusiastic teachers and students who are using the software.

- Don't allocate all the Title 1 money for hardware. It would be better by far to make fewer computers available, or make them available over a longer period of time, but make them useful by apportioning some of the funds for the acquisition of appropriate software and supporting curriculum material.

- Finally, in Section 302(a), eliminate paragraph 11. It serves no useful public purpose and simply perpetuates an outmoded and discriminatory policy that results in a watering down of the national research effort. If the rationale is to economize, there are better ways to accomplish this goal than to codify into law a built-in bias in favor of existing Federal institutions simply because they exist. The implication of paragraph (11), in fact, is that the NIE regional laboratories, among others, may be incapable of competing successfully for Title 3 funding, and thus must be "protected" by special statute. This implication is degrading to the institutions involved, and runs clearly counter to the explicit policy of both NIE and NSF to fund only the best research on a freely competitive basis.

With respect to H.R. 4628, as I have stated, I believe that this bill addresses the wrong problem by proposing the wrong solution. In its present state of development educational software needs new money less than it needs new ideas, and it is questionable whether the proposed mechanism is any more capable of producing the latter than those already in place. I do not support passage of H.R. 4628.

BIOGRAPHY OF PAUL HORWITZ, BOLT BERANWEK AND NEWMAN, INC.

Dr. Horwitz is a theoretical physicist with broad experience in universities and industry. He has taught physics on the college level, and done research in high energy and laser physics. In 1975, Dr. Horwitz was a Congressional Fellow of the American Physical Society, attached to the office of Senator Edward Kennedy, where he worked on science policy initiatives involved with university/industry collaborative research. At Bolt Beranek and Newman, Inc. he is a member of the Educational Technology Group, involved with research into innovative ways of teaching mathematics and science using microcomputers.

Mr. **Walgren**. Thank you very much. We appreciate that testimony.

Mrs. Rice.

STATEMENT OF LOIS RICE, SENIOR VICE PRESIDENT, GOVERNMENT AFFAIRS, CONTROL DATA CORP.

Mrs. **Rice**. Thank you, Mr. Chairman. I want to thank you for inviting me. And second, I wish to ask permission to provide you with some more formal testimony as part of the record, since I was asked only yesterday to testify.

I don't even have any formal written comments.

Mr. **Walgren**. Anything you submit along that line will be made part of the record.

Mrs. **Rice**. Thank you. I would like first to make some very general comments on both bills, and then move to some specific comments on each of them.

First, I would like to say that both bills recognize and underscore the power and the potential of technology in the learning process, and I applaud them for that. And one bill or another addresses critical problems in the use of computers in schools.

I do underscore, as so many others have before me, that there is in many ways a dearth of quality courseware or software available on many, many microcomputers in the schools.

I think that the general issue of inequity, which I want to applaud Mr. Wirth for addressing, is perhaps the most persistent problem in our country, not simply in education, but in other arenas as well.

And the gaps that exist between richer schools and poorer schools in the use of computers is just simply exacerbating the inequities that persist between rich and poor and black and white.

Many have cited the statistics on the distribution or the disparities in computers by types of school systems, or big city schools and suburban schools. You heard earlier 30 percent of the schools nationwide seem to have some kind of computer with more of them at the secondary level than the elementary level.

If you look at the State of Alabama, with more than 40 percent minority students, the State of Louisiana, the State of Mississippi, Alabama schools, only 9 percent of them have computers. Thirteen percent in Mississippi. Twelve percent in Louisiana.

I think that that rather dramatically addresses some of these problems.

I think the thing that more than anything else brought me to Control Data, as someone who has spent most of her life in education and trying to work for social justice and equal opportunity is when I saw the students in an innercity high school in Baltimore who were the troublemakers of that school, the truants, or the potential dropouts, turned on to learning because of the computer, I think that was really the power of the computer, and this is somehow the environment, the interactions, I think, Dr. Horwitz was talking about. Somehow it is private with them.

They were not ostracized any longer by their peers or teachers. Suddenly, they were turned on to learning. And I think these gaps that exist in the availability of technology between rich and poor schools, it is really the poor schools that need them the most.

It is not just a matter of equalizing. I think there should be an attempt here to put those terminals and those computers in those places where we have proven they can do the most good. And third, I think that the critical issue that this legislation does address is the need for teacher training.

Congressman Wirth underscored the problems of the sixties this morning. I am old enough and grey enough to have been working in this town in the sixties.

I want to underscore they put that equipment in the schools, and it was locked up in closets and teachers ran away from it because they were not trained. Here I might add this is an area, despite all of the testimony you heard from NSF, the Department of Education this morning—it is the teacher training element in their activities with technology that seems to be missing.

It is barely funded and supported at all.

I might just move quickly to a couple of thoughts on each of the two bills. One of the major findings of Mr. Gore's bill, H.R. 4628, is that the "vast majority of educationally oriented computer software now available is of less than adequate quality."

I am delighted that he said the vast majority and not all, because I think that there has been very little understanding—although it was mentioned earlier in this hearing—of the large, large extent to which Control Data, initially with the help from the National Science Foundation and the University of Illinois, has spent 20 years developing PLATO computer based education.

We have a long-term strategy with a great many things, and this has probably been the longest. It was only in the final quarter of 1983 that PLATO turned a profit.

So we have stuck with it. I would like to just mention two uses of PLATO where I think it has been extremely useful. But I would like to just go back to a point Mr. Horwitz made as well.

When I mentioned PLATO was a combined effort between the University of Illinois, the National Science Foundation and Control Data, I want to underscore that we have developed this courseware over these many, many years through a series of partnerships.

And I don't think this legislation does enough to bring the various interested parties together. I am not asking for direct support for Control Data. But I do think that we should, as the math-science bill did earlier in the House, foster partnerships to address some of these critical needs.

We have had relationships with 140 universities, hundreds of courseware developers, secondary schools, Government foundations, large and small companies and individuals. And through these cooperative efforts we have developed over 8,000 hours of high quality courseware.

As I said earlier, we have spent nearly a billion dollars on this, and 20 years of effort. In fact, I think in many ways that Control Data's PLATO software is, in fact, a software corporation pretty much of a kind that Mr. Gore himself was envisioning.

And PLATO, indeed, could well be a standard for other software developers.

PLATO began with a specifically designed terminal linked to a large central computer. But PLATO offerings are now also available on our own microcomputer, CD-110, and our Vikings. And we, unlike a lot of other companies, are adapting PLATO courseware to other microcomputers, such as Texas Instruments, Atari, the IBM PC, Zenith, and to some extent the Apple.

So it is unlike what Secretary Bell said, at Control Data, in the committee's report from the House Education and Labor Committee. He stated "there is an understandable desire on the part of corporate executives and others after they spend money on software to sort of see that it is exclusively available for their brand of computer."

We are developing software over and over again for the use on other people's equipment. I'll mention just two PLATO programs.

Our program of basic skills that begins with the first to fourth grade and continues through high school equivalency. The curriculum requires a minimum amount of instruction involvement.

Hence, it involves schools and colleges in an economic and effective means for students to gain competency in basic skills. By that I mean the skills required to begin to master more advanced math and science programs as well as other curricula.

The second program that is currently underway is something called the PLATO Lower Division Engineering Curriculum. This, too, is a partnership. The consortium, initially started with Control Data working with the engineering schools of the University of Minnesota, Nebraska, Delaware, Arizona, California State and Florida State.

We are now working with 110 other schools that offer engineering curriculum. We are developing a freshman—complete lower division freshman and sophomore curriculum in engineering and math and science and computer literacy and other programs. That lower division engineering program, is now being used increasingly at the secondary level, particularly in areas where there are shortages of math and science teachers.

So my first point is that I don't think that we need absolutely to rediscover the wheel, that there is a great deal that is currently going on.

Second, I think in terms of the Gore bill I would like to touch on an effort that is a little bit vexing and troubling to me, and I am not sure it was intended. There is in the first title the foundation or the corporation that would develop, and I quote, "criteria for the selection of high quality software."

I do tend to agree with some others before me that that does move possibly close to some of the first amendment questions and questions in the general provisions of the education act, moving to what should be taught.

I recognize, however, there is nothing in that legislation that says that this would be imposed on schools or schools would have to take it. But I think I would tend to, if I were the committee, to consider amending that language, if you are marking up that bill, and to establish a process more like in the Wirth bill for evaluating existing software and courseware rather than selecting it.

And I think that part of that process would be some of the things that we do at Control Data in terms of production testing, field or beta testing well before anything goes out to a school system.

I also have another problem with the Gore bill where I think there is an undue emphasis on initial capital needs. It seems to suggest that these are new companies rather than some that are very much ongoing, new efforts at courseware development such as companies like us or in cooperation with universities.

Universities are cooperating on the development of PLATO. I would hate to see—I don't think it was intended—that these are new efforts only rather than the infusion of funds to do some ongoing efforts, also that are inadequately funded at the present time.

On Mr. Wirth's bill, I want to underscore again that I do applaud his recognizing these grave disparities between rich and poor districts. I wish he would go further not to simply equalize but to address the crying needs in inner cities and poorer schools.

Second, I agree with Mr. Horwitz, there is probably a little too much emphasis in the Wirth bill on the purchase of hardware and not enough on software. I don't agree with my colleague from Apple that the definition of computer hardware in the Wirth bill is adequate. I think that once one puts into legislation what is at the lowest end of the line, and that is what this is, that you encourage schools to buy at the lowest end of the line. That is part of the problem now. There are a lot of rather inexpensive computer terminals to which we will not be able to adapt some of the sophisticated courseware we want to develop.

The legislation doesn't mandate that they buy at the low end of the line. It says "at least have this capability." As the language now reads, it would eliminate the MacIntosh, the IBM PC, the Zenith—not eliminate them—schools could go beyond and buy those things, but it seems by that very low level definition to encourage a minimal kind of purchase on the part of schools, and I think we want to get the best of the materials into the schools.

Finally, I would like to underscore once again that I wish under the teacher training section of Mr. Wirth's bill that he would encourage far more cooperative efforts between business, government, and education. The math-science bill in its plans and authorization of training would make grants to foster joint programs between business, industry, government, and educational institutions.

So much of the expertise, particularly in computer literacy and computer training and software development, is in the private sector, the for-profit sector, that I do think training teachers in these settings or the facilities to some degree as in the math-science bill under this legislation, sharing equipment, sharing instruction, donating and sharing the best of our teachers and our personnel from the business world and infusing them into the teacher training programs. That would indeed strengthen the bill and I urge you to look back at the language specifically in the math-science bill that I think does quite a good job in fostering those partnerships.

[The prepared statement and biographical sketch of Mrs. Rice follow:]

June 5, 1984

TESTIMONY OF LOIS RICE, SENIOR VICE PRESIDENT OF CONTROL DATA CORPORATION

Ms. RICE. Thank you. I would like first to make some very general comments on both bills, H.R. 4626 and 3750 and then move to some more specific comments on each of them.

Both bills recognize and underscore the power and potential of technology in the learning process, and I applaud the authors for that. And one bill or the other addresses three critical problems: 1) quality of much computer software; 2) the inequitable distribution of computers among differing types of schools; and 3) the pressing need to train teachers in the use of technology.

I want to emphasize, as so many earlier witnesses, that there is in many instances a dearth of quality courseware or software available on many of the microcomputers in schools and, as a result, many teachers have become disillusioned with the technology itself.

Then there is the equity issue -- or the disparities in computer resources between rich and poor school districts. It is a persistent problem. Mr. Wirth deserves great praise for recognizing and addressing this issue.

The gaps that exist between richer and poorer schools in their use of computers are just simply exacerbating other educational inequities between rich and poor and black and white.

Others have cited statistics on the distribution of computers among inner city and suburban schools. You've heard earlier that nationwide 30 percent of schools have some kind of computer equipment with more of them at the secondary than at the elementary level.

In the States of Alabama, Louisiana, and Mississippi all with more than 40 percent minority students, only 9 percent, 12 percent and 13 of the schools respectively have computers.

Those statistics dramatically illustrate the disparities in resources.

What enticed me to join Control Data -- someone who had spent her entire career in education trying to work for social justice and equal opportunity -- was seeing students in an inner-city Baltimore high school who were the troublemakers, the truants, and the potential dropouts, turned on to learning because of Control Data's PLATO and its power.

For these students, poor and black, PLATO provided a private learning experience -- one that praised them for their achievements. Suddenly they were freed of ostracism and real or perceived rejection from their peers and teachers and, as the students demonstrated a new found potential, they were suddenly perceived as educable.

But the issue is not simply one of equalizing computer resources between rich and poor schools. Rather we should concentrate those terminals and computers in places where we have proven they can do the most good -- capable of improving the performance of the neediest students.

Finally, the legislation addresses the need for teacher training. Congressman Wirth earlier described the lessons of the sixties. In the sixties, I saw federally funded equipment in the schools locked up in closets. Teachers ran away from the new technology because they did not understand it and were not trained to use it. And despite all of the testimony you heard this morning from NSF, and the Department of Education, neither agency in their technology effort is focussing on "teacher training". Such training is barely funded or supported at all.

Now I might just move quickly to some comments on each of the two bills. One of the major findings of Mr. Gore's bill, H.R. 4628, is that the "vast majority of educationally oriented computer software now available is of less than adequate quality."

I am delighted that he said the "vast majority" and not all, because there seems to be very little understanding of the large and long commitment that Control Data (initially, with the help from the National Science Foundation and the University of Illinois,) has spent developing PLATO computer based education.

We have a long-term strategy for a great many CDC efforts. PLATO has probably been the longest. After 20 years of investment and effort it was only in the final quarter of 1983 that PLATO turned a profit.

We have stuck with PLATO. I would like just to mention two uses of PLATO where it has been extremely helpful to students and also in addressing teacher shortages in critical fields of study.

When I mentioned PLATO was a combined effort between the University of Illinois, the National Science Foundation and Control Data, I meant to underscore that we have developed these courses over these many, many years through a series of partnerships and in my view neither bill does enough to bring the various interested parties together. I am not asking for direct support for Control Data. Rather we should, as the House math-science bill recognizes, foster partnerships to address some of the critical needs, such as software development.

Control Data has had relations with 140 universities, hundreds of courseware developers, secondary schools, government, foundations, large and small companies and individuals. And through these cooperative efforts we have developed over 8,000 hours of high quality courseware.

We have spent nearly a billion dollars on PLATO, over a 20 year period. In many ways Control Data's PLATO effort is, in fact, a software corporation pretty much of the kind that Mr. Gore himself envisages.

And PLATO, indeed, could well be the standard for other software developers.

PLATO began with a specifically designed terminal linked to a large central computer. PLATO offerings are now also available on our own microcomputers -- the CD-110, and Viking. And we, unlike a lot of other companies, are adapting PLATO courseware to other microcomputers, such as Texas Instruments, Atari, the IBM PC, Zenith, and, to some extent, the Apple.

So at Control Data it is unlike what Secretary Bell said in the committee's report from the House Education and Labor Committee. "There is an understandable desire on the part of corporate executives and others after they spend money on software to sort of see that it is exclusively available for their brand of computer."

We are developing software for the use on other vendor's equipment. I'll mention just two such PLATO programs.

Our program of basic skills begins at the third grade and continues through high school. The curriculum requires a minimum amount of teacher involvement. Hence, it is an economical and cost effective means for students to gain competency in basic and other skills required to begin to master more advanced math and science programs as well as other curricula.

A second program currently underway is something called the PLATO Lower Division Engineering Curriculum. This is a partnership that initially started with Control Data working with the engineering schools of the University of Minnesota, Nebraska, Delaware, Arizona, and California State and Florida State.

We are now working with more than 100 colleges that offer an engineering curricula to develop a complete lower division freshman and sophomore curriculum in engineering, math, science, computer literacy, and other lower division programs and these courses can be used at the secondary level, particularly in areas where there are shortages of math and science teachers.

So my first point on Mr. Gore's Software Corporation is that we don't have to re-discover the wheel. There is indeed a great deal currently going on in industry and universities to develop quality software.

Second, in terms of the Gore bill, I would like to touch on a somewhat vexing provision that may have been unintended. In Title I the foundation or the corporation would develop, and I quote, "criteria for the selection of high quality software."

As others have suggested, that provision could raise some first amendment questions and also questions relating to the general provisions of the education acts, concerning the role of the federal government in "what should be taught".

I recognize, however, there is nothing in the Gore bill that says that the software the Corporation selects would be imposed on schools. Still I would urge that the committee consider amending that provision to establish instead a process for selecting and evaluating courseware similar to that suggested in Mr. Wirth's bill. That process could be similar to the one we use at Control Data that involves production testing and field or beta testing well before courseware goes out to a school system.

Still another concern with H.R. 4628 is its seeming emphasis on meeting the initial capital needs of new software companies. Many ongoing efforts in courseware development involving cooperation between universities and business are inadequately funded at the present time and also need help.

On H.R. 3760, Mr. Wirth's bill, I once again want to applaud his recognition of the grave disparities between rich and poor school districts. I only wish the bill went further -- not simply to equalize resources -- but to compensate even more the crying needs for technology in inner city and schools with poor and minority students.

Secondly, there is probably too little emphasis in H.R. 3760 on the purchase of hardware and not enough on providing resources for software.

Also the definition of computer hardware in the Wirth bill is inadequate. Once one puts into legislation a definition of equipment that is at the lowest end of the line, and that is what this bill does, you encourage schools to buy at the lowest end of the line. That is part of the problem now. There are a lot of inexpensive computers in schools which cannot handle some of the sophisticated courseware we ought and the bill seeks to develop.

The language in the bill, though it says "at least a 16k memory" would eliminate the MacIntosh, PLATO 110, the IBM PC, the Zenith and thereby encourage purchase of minimal capacity equipment. We should want schools to have the best and most sophisticated hardware and to encourage choices between on and off line equipment for only in that way can we utilize advanced and quality software and serve the differing needs of schools.

Finally, I would like to praise the teacher training section in H.R. 3750 and urge that the bill be amended to encourage far more cooperative efforts to train teachers between business, government and education.

So much of the expertise, particularly in computer literacy and computer training and software development, is in the private sector, the for-profit sector, that training teachers in business settings, in business facilities, sharing equipment, instruction and personnel would indeed strengthen the bill. I once again urge the Committee to review the teacher training partnership in the math-science bill and use it as a model for this legislation.

LOIS DICKSON RICE

SENIOR VICE PRESIDENT, GOVERNMENT AFFAIRS

Birthdate:	February 28, 1933
Birthplace:	Portland, Maine
Education:	Radcliffe College (Magna Cum Laude, Phi Beta Kappa) A.B. 1954 Columbia University, Woodrow Wilson Fellow 1954 - 1955 Brown University, LLD (Honorary) 1981 Bowdoin College, LLD (Honorary) 1984

EXPERIENCE:

1981 -	Control Data Corporation Senior Vice President, Government Affairs
1973 - 1981	College Board, Washington, D.C. Vice President
1959 - 1973	College Board, New York and Washington, various positions with exception of two periods: 1963 - 1964 with the Ford Foundation as an educational specialist in West Africa; and on leave as consultant with The Program in Economic Studies, The Brookings Institution, Washington
1955 - 1959	Director of Counseling Services, National Scholarship Service and Fund for Negro Students, New York City

CORPORATE BOARDS:

--Control Data Corporation, 1978...
--The Firestone Tire and Rubber Company, 1983...
--Student Loan Marketing Association (SLMA), 1978 - 1981
--Commercial Credit Company, 1977 - 1981

OTHER BOARDS AND COMMISSIONS:

--Trustee, The Potomac Institute, 1978...
--Trustee, The Urban Institute, 1976...
--Trustee, The German Marshall Fund, 1984...
--Trustee, National Institute for Work and Learning, 1983...
--Trustee, Woodrow Wilson National Fellowship Foundation 1983...
--Business Advisory Council, Graduate School of Industrial Administration, Carnegie-Mellon University 1983...
--Advisory Council, Marshall Scholarship Commission, 1983...
--Advisory Council, Johns Hopkins University School of Advanced International Studies, 1980 - 1984
--Carnegie Council on Policy Studies in Higher Education, 1975 - 1978
--Member, National Advisory Board, Institute for the Study of Educational Policy, Howard University, 1974 - 1984
--Trustee, National Humanities Center, 1979 - 1982
--Trustee, Stephens College (Missouri), 1976 - 1978
--Trustee, Radcliffe College, 1969 - 1975
--Governor's Commission on the Future of Post-Secondary Education in New York State, 1976 - 1977
--Commission on Academic Affairs, American Council on Education, 1974 - 1976
--Chairman, Visiting Committee on Afro-American Studies, Harvard University, 1974 - 1977
--Fund for the Improvement of Post-Secondary Education, 1972 - 1975
--Children's Television Workshop, 1970 - 1973
--Beauvoir School, Washington, D.C., 1970 - 1976

AWARDS AND PUBLICATIONS:

Recipient, Deborah Morton Award, Westbrook College, (1984)
--Recipient of Department of Health, Education and Welfare Award for "Outstanding Citizen" Distinguished Services to Education (1977)
--Author or Editor of numerous publications and frequent public speaker (List of publications available upon request.)
--Consultant to the former U.S. Office of Education, and the Departments of Education and Health, Education, and Welfare, the National Institute of Education, the National Academy of Education and various foundations.
--Aspen Institute Executive Seminar, 1977; Aspen Institute Corporation and Society Seminar, 1980.
--Named by CHANGE Magazine in 1978 as one of the nation's 100 outstanding higher education administrators.
--Who's Who in American Women, 1981...
--Who's Who in America, 1981...

Mr. **Walgren**. Thank you very much for that testimony. Let me pause and make a phone call and I will be right back.

Mr. McQuillen.

STATEMENT OF HARRY McQUILLEN, PRESIDENT, CBS EDUCATIONAL AND PROFESSIONAL PUBLISHING, CBS, INC.

Mr. **McQuillen**. Thank you.

Good afternoon, Mr. Chairman. I, too, appreciate the opportunity to speak before the subcommittee on what is a very important issue. I will also ask, as Mrs. Rice did, that we leave the record open for additional testimony since we were requested to testify on rather short notice.

As an educational publisher, I am here today to support both the Computer Literacy Act of 1984 and the National Educational Software Act. As an educational publisher, we agree with several of the statements made today. We feel that the microcomputer will be a very important force in education and we also feel that the positive impact on computers can be accelerated with very thoughtful programs between the public and the private sector.

While supporting the goals and objectives of the two bills, the need to accelerate the flow of hardware into schools, particularly schools in economically disadvantaged areas, and on the need to stimulate software development of a greater quality and more interactive nature and the need to provide more reliable systems to evaluate software and to train teachers, we do have serious questions and reservations regarding the vehicles recommended in the two bills to evaluate software and Federal development of software.

Let's begin with the Computer Literacy Act. Title I we agree with completely, that is, we feel there is a very necessary need for the Federal Government's involvement in seeding the schools with more hardware, particularly in the economically disadvantaged areas, and I would like to underscore a point made by Mrs. Rice. Most of the software we are developing is for more powerful computers than the one identified in the bill here. Title II of the bill we are also in complete agreement with.

As publishers, we come into daily contact with the classroom and we feel that the biggest single impediment to the development of the use of microcomputers as an educational tool is the lack of adequate teacher training. I think the devices identified in the bill are very appropriate for that task at hand.

When we get to title III of the Computer Literacy Act, it, for the first time, creates some uneasiness and concerns for us as a provider of educational material, although some of that concern has abated as a result of some of the testimony earlier today. We originally read the bill as having the Federal Government much more involved in the process of evaluating software and therefore infringing on the general provisions of the General Education Provisions Act and some of that was dispelled by some earlier testimony today. We do, however, take exception to one of the reasons for the evaluation, i.e., that the software currently available is of overall poor quality. We will discuss that later in the testimony.

I do want to make a point that currently there are several methods of evaluating software available. Some of these have developed rather recently, in the last 6 to 12 months that seem to be doing a rather effective job. There are computer user groups currently in 33 States throughout the United States often providing software preview centers and an opportunity to evaluate the quality of software. In the States where these computer user groups are not available, State departments of education have done a very good job, Minnesota being the obvious example, with North Carolina and Arkansas taking some steps toward effective evaluation of software.

In addition to that, some private, nonprofit organizations have appeared, EPIE, which stands for Educational Products Information Exchange, affiliated with Columbia Teachers College in New York City and MICROSIFT, which stands for Microcomputer Software Information for Teachers, although originating in the Northwest, is now a national service available on line that does some rather effective evaluations of software. There are software clearinghouses, there are teachers associations—the National Council of Teachers of English, the National Science Teachers Association—and other teachers' associations are now reviewing software and recommending the use of appropriate software in the schools.

Finally, there are several publications, both for the lay consumer and for the computer-using teacher, that have appeared within the last year or 6 months that do a very effective job at evaluating software and even the media itself, public television and cable systems are heightening the awareness of the public to the potential of the microcomputer as an educational tool and are assisting the public in evaluating software and hardware.

So our point is basically we feel that the Computer Literacy Act is a very positive one. We are concerned about the role of the Federal Government in terms of evaluation of software and we do feel that there are many mechanisms now and developing in the future for effective evaluation.

The second bill, the National Education Software Act, we agree certainly with four of the findings of the bill; that computers can play a valuable role in enhancing education, that in order to realize the full potential of the computer, we do need more quality interactive software and that a national effort is needed to stimulate that quality software.

We are grateful for the national attention that this issue is getting and we do applaud the sponsors' motives. However, we do not feel that a National Educational Software Corp. is either necessary, nor is it the appropriate vehicle to accomplish this. We also do not feel that the problem of inadequate software, although it did seem to be the case maybe 12 to 24 months ago, is as great a problem as identified in the bill.

In the last 12 to 24 months, several things have happened which I think have changed the role of various software publishers and their investment level in the development of software in terms of the private sector as a whole. First, the fact that sales of software have grown from $43 million 2 years ago to a projected $135 million in 1984-85, has stimulated quite a bit of interest in the private sector. The fact that schools have, for the most part settled on two or three pieces of hardware, with Apple, Comodore, and the TR-80 being the three major computers in schools, has helped us in terms of software development, and finally the fact that both State and local textbook adoption committees are now requiring software as part of the evaluation process.

These three trends have stimulated in the last 24 months a major interest and investment in software on the part of traditional textbook publishers, which we represent with Holt, Rinehart and Winston. For the most part, they have worked with the mom-and-pop developers and begun weeding out, if you will, the inferior software and started using traditional expertise in terms of working with local teachers and local education associations and with consultants and authors to introduce real quality into the software that is being developed.

We estimate at CBS alone this year to be investing approximately $20 million in terms of the development of educational software. I think my estimate of $100 million as an investment level for software publishers this year is probably modest when you look at that number alone.

The point I want to make in summary is that the private sector, particularly educational publishers, have awakened to the potential of this market. We are investing actively, developing software with private new software developers, with educational institutions, like the Bank Street College, with educational testing and systems developers and a wide range of people. The kind of software we are developing is everything from drill and practice which plays a role in the classroom to much more sophisticated computer simulations, so the state of things is improving dramatically.

Finally, a couple of notes on the issue of a National Educational Software Corp. We do very much feel that Federal Government support is needed in the continuing development of educational software, but we feel that currently several of the agencies and departments existing in the Government can accomplish this objective and there is really no need to develop an entirely new corporation. As a corporate executive, I do see some issues that concern me in the suggestion of a national corporation for software development.

First of all, the corporation's primary goal which is to improve the quality of software, I think, is currently being accomplished through the teamwork of publishers and Federal Government agencies and departments like the U.S. Department of Education and the National Science Foundation. Second, I was somewhat concerned with the criteria used to evaluate where the corporation was going to invest their money.

If you read the critiera, they were looking for projects that have commercial success and most likely return on the investment. There are very few quality software projects out there with the potential for success in the market and return on investment that are not currently being seeded by corporations. Our concern is finding those projects, not an investment issue. So I am afraid this corporation would be competing with what is going on in the private sector. I suggest that we take that $15 million and maybe a larger amount and invest it in pockets of research and experimentation and development of software rather than compete with the private sector right now in terms of a corporation.

The third issue related to a national corporation is I think that the establishment just in name alone of a National Educational Software Corp., would intimidate several members of the private sector. It might be viewed as the Federal Government becoming involved in the private part of the market and I think that is something we do not want at this point.

Fourth, and finally, I was concerned that the national corporation as defined in the bill would have to develop several skills at great expense and a great deal of manpower to actually pull off the objective of developing more quality software, skills that already exist in the private sector, marketing research, a network of communication with teachers and authors, financial skills and a variety of other skills that already exist in the private sector.

So we support the direction of the Gore bill, the need for more Federal funding to develop quality software. However, we do not think that the vehicle, a national corporation is the appropriate way of accomplishing that goal at this time and we do support the Computer Literacy Act with the exception of some issues on evaluation.

Thank you.

[The prepared statement and biographical sketch of Mr. McQuillen follow:]

TESTIMONY OF HARRY A. McQUILLEN
PRESIDENT, CBS EDUCATIONAL & PROFESSIONAL PUBLISHING

BEFORE THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON SCIENCE, RESEARCH & TECHNOLOGY
June 5, 1984

As an educational publisher I am here today to applaud the objectives of the "Computer Literacy Act of 1984" and "The National Educational Software Act." The microcomputer will be an important force in education in this country and a valuable tool for students and teachers, and the positive impact of computers on education can be accelerated by thoughtful action on the part of the private and public sectors.

While supporting the goals and objectives of the two bills, i.e., the need to accelerate the flow of hardware into schools (particularly schools in economically disadvantaged areas), the need to stimulate the development of more quality interactive educational software, and the need to provide reliable systems to evaluate software and train teachers, I have serious questions and concerns regarding the vehicles recommended in both bills for the development and evaluation of software.

Let's begin with H.R. 3750, "The Computer Literacy Act of 1984." It is very clear that Title I, "Acquisition of Computer Hardware," is necessary. Publishing industry data supports the statistics cited in the bill. We estimate that by the end of 1984 nearly 400,000 microcomputers will be in our elementary and secondary schools. On the surface this seems like a large number and suggests dramatic progress. However, these micros are heavily concentrated in more affluent school districts and projections show that we will not achieve a ratio of 30 students per computer until 1987 (See Appendix 1 for our hardware projections). Under these conditions it seems necessary for the federal government to assist in building the base of microcomputers in schools. The methodology defined in the bill for determining how, when and where hardware funding will be allocated seems appropriate for the challenge at hand.

Title II of the "Computer Literacy Act of 1984", aimed at developing teacher training institutes, is another necessary step in the integration of the microcomputer into the classroom. As publishers working with classroom teachers on a daily basis, we have concluded that the lack of teacher training on micros is the biggest single impediment to their use. The private sector has not effectively addressed the issue of computer training for teachers. There is neither an existing structure nor one on the horizon to provide this training. So the federal government will fill this void. Using National Science Foundation grants and contracts to non-profit teaching and technical organizations as the vehicle for accomplishing the training is an ideal short-term solution which should efficiently accomplish the training objective.

As I read Title III of the "Computer Literacy Act" it grants the federal government a major role in the evaluation of available computer hardware and software. This is the only section of the bill which creates a great deal of concern and uneasiness for publishers of educational materials. Our concern and anxieties revolve around three major issues.

(1) It is an important tradition in this country that education remain the province of state and local authorities. The development of curriculum materials, texts, teacher support resources, etc. has historically been the exclusive right of state and local agencies. As the minority views of H.R. 4628 point out, Sec. 432 of the General Educaion Provisions Act covers this issue.

> Sec. 432. No provision of any applicable program shall be construed to authorize any department, agency, officer, or employee of the United States to exercise any direction, supervision, or control over the curriculum, program of instruction, administration, or personnel of any educational institution, school, or school system, or over the selection of library resources, textbooks, or other printed or published instructional materials by any educational institution or school system, or to require the assignment of transportation of students or teachers in order to overcome racial imbalance.

The dangers of a centralized federal evaluation mechanism for educational materials are obvious to everyone. I want to emphasize that software is clearly, like a textbook, part of the family of educational materials to be guarded and protected from federal control. And although federal evaluation and model building do not represent direct control, they threaten the very important principle of decentralized education in this country.

(2) The need for an evaluation mechanism arises from an alarm or concern over the quality of available educational software. This issue will be treated in some detail later in the testimony when H.R. 4628 is being discussed. The point I wish to make now is that over the last year the quality of educational software being published has improved dramatically. This improvement has occurred for a variety of reasons detailed later in this testimony, and it will be documented in some detail. What is important to note here is that evaluation as a protective device for the consumer of software is becoming less necessary as the quality of published software is upgraded.

(3) Twelve to eighteen months ago the need for mechanisms to evaluate software was greater than it is today. Over the past two years, and in particular over the past six to twelve months, several sources for evaluating software have been created which make the proposal of a federal evaluation process unnecessary.

The sources available to teachers for the review and evaluation of educational software are many and growing at an explosive rate.

Computer User Groups

Over 33 states currently have computer user groups for teachers and many of them are reviewing and evaluating software as well as promoting computer use in the classroom. In states without statewide user groups, the State Departments of Education are filling the needs with special services for the assessment of hardware and software both from a needs and implementation point of view and product review and evaluation. Many states have created software preview centers where educators can come and try out many educational software programs at no charge. These services are being utilized by school districts, administrators, teachers, and parents.

State Departments of Education

In states where evaluation of educational materials are part of a well established program, the review of computer courseware has increasingly become a part of these evaluations. The Minnesota Educational Computing Consortium (MECC) is an outstanding example of a statewide effort to provide such services to the public. MECC has been so successful that other states and groups from all over the country have sought their advice and services. North Carolina and Arkansas are examples of two other states where aggressive statewide efforts are under way to provide review and assessment services for computer courseware.

Private, Non-profit Organizations

Several non-profit organizations have also started software evaluation and review services. Two such organizations providing services nationwide are Educational Products Information Exchange (EPIE) and MICROSIFT. EPIE is based in New York and affiliated with the Columbia Teachers College and Consumers Union. MICROSIFT is affiliated with the Northwest Regional Educational Laboratory in Portland, Oregon.

EPIE Institute and MICROSIFT

EPIE was started in 1974 to evaluate educational materials and has been evaluating computer software since 1979. MICROSIFT, which stands for Microcomputer Software Information for Teachers, also began evaluating software in 1979. Based in Oregon, their primary service sector is the northwest, but their software review services are available nationally, in Canada and the Pacific through a network of 225 educational organizations. They are also available through the on-line data base service of BRS. EPIE subscribers come from all parts of the country and benefit from EPIE's bimonthly reviews of software and hardware products as well as TESS: the Educational Software Selector. TESS is a reference guide listing over 6000 educational programs currently available and is updated quarterly. EPIE is updated quarterly and is now available to consumers through the CompuServe network, where users can electronically access EPIE software and hardware reviews and TESS.

MICROSIFT provides its quarterly evaluations free of charge to the 225 educational organizations who in turn provide it at no charge or at cost to cover reproduction to educators. EPIE subscription fees range from $105 per year to $360. But there are many other sources of software evaluation that are free to educators.

Software Clearing Houses

In addition to these two services, information on educational software is available through several clearing houses. The ERIC clearing houses are sixteen national educational clearing houses that cover subjects as wide-ranging as pre-school and early childhood education to education for the handicapped and special needs children. Many of these services are cataloging computer software in their specialties.

Teachers Assocations

Teachers associations such as the National Council of Teachers of English, the National Science Teachers Association, the National Council of Teachers of Mathematics are preparing guidelines for software evaulation and organize conferences on computer use in the schools that provide opportunities for educators to meet and discuss needs as well as see and test software. Many teacher organizations provide their members with software reviews and articles via their newsletters and journals.

Publications

Many publications have started in the past three years that address the particular needs of computer-using teachers. Electronic Learning, Classroom Computer News, Electronic Education, The Computing Teacher are just a few of the many publications that provide teachers with review and evaluations of software and hardware products. Many general interest magazines also cover software reviews of educational programs. Family Computing, Compute and Creative Computing are examples of such journals that treat educational software seriously.

Media

Television has also recently begun to play a role in making people aware and informed of the educational capabilities of computers. Local cable systems and Public TV stations are offering programs on computing that cover hardware and software issues of interest to educators, parents and computer-users in general.

SOURCES OF EVALUATION------EDUCATIONAL SOFTWARE

INDIVIDUALS

- Computer User Groups
- Teacher Associations

ORGANIZATIONS

- State Departments of ED.
- Private Non-Profit Organizations
- Regional and National Consortia
- National Educational Clearing Houses
- Software Preview and Resource Centers
- On-Line Data Retrieval Services
- Computer Research Centers
- Hardware Manufacturers

MEDIA

- Computer Journals and Publications in Education
- General Interest Computer Journals and Publications
- Local Cable TV and Educational TV Programs
- Compuserve

NOTE: Available with this testimony are several documents which provide further information on how the evaluations by the above are carried out. See Appendix 2.

In summary, we have seen an explosive development during the last twelve to eighteen months of resources for teachers to use in reviewing and evaluating software. These resources are expanding, developing and improving at a rapid rate and would seem to negate the need to establish a national evaluation program. We believe it is far more desirable to have our educational system rely on several diverse views.

Now let's turn to the "National Educational Software Act of 1984", H.R. 4628. As educational publishers we agree with three of the four findings on which the bill is constructed.

(1) Computers can play a valuable role in enhancing the quality of education in this country.

(2) High-quality interactive and educationally useful software is essential to enable the tremendous educational potential of computers to be realized.

(3) A national effort is needed to encourage the development of useful, high-quality software for our nation's schools.

We are grateful for the national attention granted this issue and applaud the motives and interest of the bill's sponsors. however, we disagree with the finding that "the vast majority of educationally oriented computer software is of less than adequate quality," and we contend that the quality of educational software has and will continue to improve dramatically. Also, we do not feel that a national educational software corporation, as defined in this bill, is required to accelerate the development of quality software. We believe that the federal government already has in place adequate mechanisms to drive the "national effort" required to improve software.

The educational software business has shown characteristics and trends common to all embryonic businesses. The first software available for the school market was very primitive. It came directly from inexperienced developers to market and was purchased indiscriminately by schools because it was the only thing available. As the market for software took on definition in 1981 and 1982 the number of software titles and developers increased, and standards were developed to begin to define quality software. From that point on, not all software reached the market, as software publishers weeded out poor quality software and developed and improved software to better meet the needs of the schools.

Recently, the development of software has exploded, sales have grown from only $43 million in 1982-83 to a projected $135 million in 1984-85. Schools quickly settled on three hardware choices and school adoption committees required software packages to be integrated with their curricula and texts. These changes motivated large, knowledgeable publishers with long-term commitments to education to move rapidly into software, replacing some "Mom and Pop" developers but integrating many others into the expanded market as suppliers or authors.

hardly a major publisher exists who has not directed their attention to courseware. The American Association of Publishers (AAP) has formed a technology committee whose members include representatives of, among others, John Wiley & Sons, Science Research Associates, Reader's Digest, D.C. Heath & Co., CBS Publishing, Harper and Row, Little, Brown & Co., World Book Encyclopedia, McGraw-Hill, Prentice-Hall, Simon and Schuster, and Bantam Books. Electronic Learning Magazine, a major source of technological information for the education community, included advertising for courseware from the following publishers in its last three issues: Bobbs-Merrill, Houghton-Mifflin, The Learning Co., McGraw-Hill, Random House, Reston Publishing, Scholastic Publishing, Sterling Swift, John Wiley & Sons, Addison-Wesley, D.C. Heath and Co., Milliken Publishing, Scott, Foresman and Co., Rand-McNally, Reader's Digest, Encyclopedia Brittanica Education Corp., and Simon and Schuster. We estimate that the combined commitment of these publishers represents a dollar investment in educational courseware of $100 million a year with more publishers entering the field every day. Apple Computer, Inc., whose machines represent more than 50% of the computers in use in schools at this time, estimates that there are approximately 2600 courseware programs presently available for use on its computers alone; each of these programs may consist of several discs for use at various student levels.

Although some publishers have established separate electronic publishing companies to distribute materials for the home education market, most of the major publishers of curricular materials have chosen to keep their courseware units within their established school publishing departments; this is true, for instance, of Holt, Rinehart and Winston,* Random House, HBJ, Heath, Wiley, McGraw, Prentice-Hall, Addison-Wesley, and Reader's Digest.

There is a good reason for that pattern. The major educational publishers have been preparing curricular materials for many years (in Holt's case, for over 100 years). They are sensitive to the needs of students, teachers, and local communities and have always created their traditional materials with the guidance of authors and consultants who are working members of the educational community. For many years, publishers have helped to create curricula and design teaching strategies. Because of the open competitive nature of educational publishing in our country, local school systems have been able to choose from a diverse body of materials that best suit the needs of their particular students.

---

* Holt Rinehart and Winston publishes for the elementary and high school market within CBS Publishing.

Publishers are now beginning to incorporate courseware into their programs. Holt, Rinehart and Winston's 1985 Elementary Mathematics program includes a courseware package for each grade with citations in the Teachers Edition indicating when each disc is to be used. We are also in the process of preparing for publication a series of programs to accompany Basic Reading texts with computerized lessons directly keyed to specific units in the books. Holt has already begun preliminary preparations for courseware for its future editions of Holt Basic Reading as well as for its Music Series, and its other basal materials. Although publishers do not share their future publishing plans with their competitors, it would seem safe to say that the other major houses are going through the same process.

Holt, Rinehart and Winston has formed an Electronic and Media Publishing Program within its school unit to produce high-quality courseware to accompany its curriculum materials. Holt's current budget commitment to the development and marketing of courseware is in excess of $2.5 million. This commitment is expected to grow in future years as courseware is planned to accompany more and more of Holt's classroom materials.

The Electronic Unit has reviewed more than 200 different programs in the last year to assess their suitability for publication and less than fifteen programs were found to be suitable for publication. These programs have come from educational institutions, established software developers, and young programmers with new ideas. The programs selected for publication include those from institutions (Bank Street College of Education), computer systems developers (Cygnet Systems Corporation), motion picture producers (Keron Productions), and specialists in educational testing and systems development (Williams and Weisbrodt).

The products that Holt School has chosen to fund and distribute range from traditional skills practice (The Reading Skillsbase) to state-of-the-art computer simulations (SciSoft Adventures in Science Series), and from simple, one-disc programs (Wordfinder) to advanced multi-media programs that include video, books, and computers (Bank Street Project in Science and Mathematics). Holt's products include both programs for Computer Assisted Instruction (CAI) and Computerized Classroom Management and Testing (CMI).

Holt is selling its courseware through its traditional national sales force and through specially selected courseware consultants. These sales people have daily contact with classroom teachers and school administrators. They bring the courseware directly into the schools so that buyers do not rely on magazine advertisements or mail-order catalogs to make their selections.

In conclusion, we believe that the educational software industry is maturing quickly and in that maturation process is introducing a new generation of software far superior to the inadequate drill and practice software that stimulated the National Educational Software Corporation Bill. They are developing software standards and a process for pinpointing poor software, improving good software, and using an established marketing network that will continue to identify the schools' needs and incorporate them into future courseware. (See Appendices 3 and 4 for more information on software development.)

However, this dramatic improvement in the development process of school software does not negate the need for continued support by the federal government. Three examples come to mind which show how government funding was put to good use for the development of classroom computer materials. One is the story relating to the funding for the first stages of the development of the Bank Street College Project in Science and Mathematics by the Division of Technology Resource Assessment and Development (The Center for Libraries and Education Improvement) of the U.S. Department of Education. The others involve grants by the National Science Foundation and the National Institute of Education to individuals who later became either publishers or significant developers of materials for large publishing companies; these grants involve the Learning Company and Keron Productions. (See attached histories of Bank Street, Xeron, and the Learning Company in Appendix 5.)

These examples reinforce the fact that we need not establish a national educational software corporation to encourage a national effort for the development of high-quality, interactive, educationally useful software. The National Science Foundation, the Department of Education and other existing federal agencies and departments can, with focus and additional funding, stimulate a national effort to improve software.

We do not support the establishment of a national educational software corporation for the following reasons:

(1) The corporation's primary goal, the development of quality interactive educational software, is well on its way to being accomplished by teamwork between a recently stimulated collection of publishers and existing federal agencies. However, it should be noted that the dramatic improvement in the software development system is a very recent phenomenon and it was not predictable at the time that this bill was conceived.

(2) According to the criteria for investing in software projects currently stated in the bill, a national corporation might not stimulate the development of

innovative quality software with its $15 million a year expenditure. If a national corporation invests only in projects with a reasonable chance of success and return on investment, it will largely compete with private industry for some of the more imaginative software currently being developed. On the other hand, if the government, through the NSF or other appropriate agencies, uses the $15 million to stimulate or create pockets of experimentation and research in software that are not commercially viable it would complement private industry's current investment and more likely facilitate the new, fresh state of the art software required.

(3) The establishment of a national software corporation would very likely intimidate the private sector and could result in a decrease in overall investment by companies currently developing quality software. As we noted earlier, hundreds of quality publishers are currently investing approximately one hundred million dollars a year in software for schools. There is no question that the existence of a national corporation for software development would chase many investment dollars out of software, because publishers would not want to compete in a busines with a national corporation.

(4) The national software corporation's charter would include developing criteria for the selection of software, disseminating information on this software, and "engaging in such other operations and activities as the Board of Directors determines to be necessary and appropriate to encourage the development and use of such software." As noted earlier in my testimony, these activities clearly endanger the traditional separation of the federal government from education and educational materials and may even create potential problems in First Amendment censorship areas.

(5) To develop an effective national corporation for software the federal government would have to develop a wide range of skills and mechanisms including market research, a communication network with thousands of school districts, personnel to evaluate and monitor software, financial skills, etc. Most of these skills have already been developed by publishers and are being put to use on a daily basis in the software market.

In summary, we feel that the goals and objectives of H.R. 4628 are laudable. However, establishing a national software corporation to accomplish them does not seem necessary.

HARRY A. McQUILLEN, PRESIDENT, CBS EDUCATIONAL AND PROFESSIONAL PUBLISHING

Harry A. McQuillen is President of CBS Educational and Professional Publishing (CEPP), a division of CBS Inc. He was appointed to that position in April 1983.

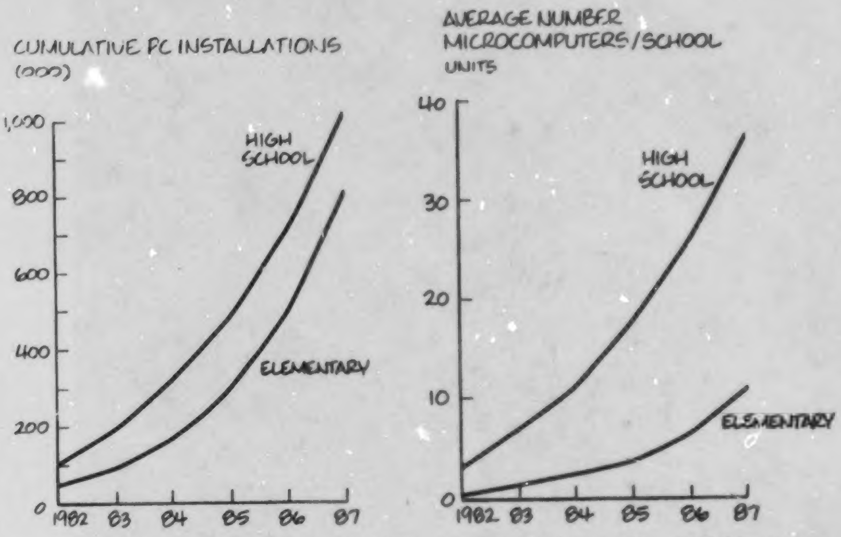
Prior to his appointment as President of CEPP, Mr. McQuillen was President of the CEPP College Publishing unit. In that capacity he developed the unit into one of the industry's most innovative, successful and respected college publishers. He joined CEPP in 1977 as Vice President, Editor-in-Chief, in the College Publishing unit and subsequently served as Vice President, Marketing and Sales, in that unit. Before joining CEPP, Mr. McQuillen was Marketing Director in the College Department at McGraw-Hill and held sales, marketing and editorial management positions at McGraw-Hill and Prentice-Hall.

Mr. McQuillen holds a B.A. from Villanova University.

APPENDIX I

PROJECTED NUMBER OF PERSONAL COMPUTERS IN U.S. SCHOOLS

. . . fueled by increasing penetration of PCs in schools.



SOURCE: FUTURE COMPUTING, DEC. 1982; MARKET DATA RETRIEVAL, 1983

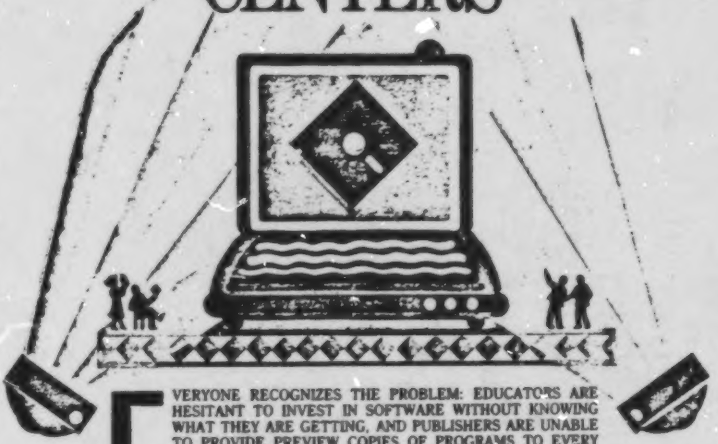
BEST COPY AVAILABLE

APPENDIX II

EXISTING EVALUATION SOURCES FOR EDUCATIONAL SOFTWARE

EL'S *NATIONAL DIRECTORY OF*

SOFTWARE PREVIEW CENTERS



EVERYONE RECOGNIZES THE PROBLEM: EDUCATORS ARE HESITANT TO INVEST IN SOFTWARE WITHOUT KNOWING WHAT THEY ARE GETTING, AND PUBLISHERS ARE UNABLE TO PROVIDE PREVIEW COPIES OF PROGRAMS TO EVERY TEACHER WHO WANTS TO TAKE A LOOK BEFORE BUYING.

There is an alternative—one that can satisfy the needs of both groups. Regional software preview centers can provide educators with an opportunity to look at a large quantity of programs without having to spend a cent. They can also provide publishers with a forum for showing software to large numbers of teachers at a reasonable cost (and without having to worry unduly about copyright infringements).

Preview centers have already sprung up all over the country. They are sponsored by state education agencies, universities and teaching colleges, and regional teacher centers, as well as commercial organizations such as computer manufacturers and dealers. What's been lacking has been a central directory of all (or most) of these centers, for use by both educators and publishers seeking a forum to show their products.

EL's *National Directory of Software Preview Centers* represents, to our knowledge, the first publication of such a list. Part I, which begins on the following page, covers states west of the Mississippi. Part II, covering the remaining states, will appear in the February issue of *EL*.

Unless otherwise noted, a center's program inventory covers all academic subjects for grades K-12. For reasons of space, only non-commercial centers have been listed; check with your local dealer about the possibility of previewing software in the shop.

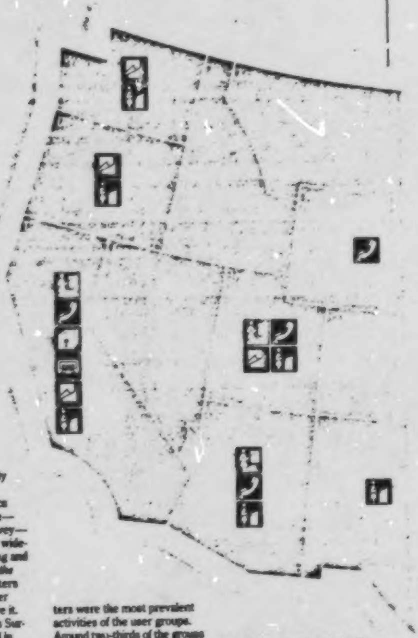
—*The Editors*

Research for this article was conducted by Kate Christen and Debbie Michel

Illustration by Colin Johnson

EL'S SECOND ANNUAL
Survey of the States

State User Groups



THE GRASS ROOTS of educational computing have never been healthier. Over the past year, in fact, they have become positively robust.

That seemed to be the consensus among educators contacted by *EL* for the magazine's Second Annual Survey of the States. In an effort to determine the level of grass roots interest in educational computing across the country, *EL*'s researchers combed each state for what may be the most visible sign of that interest: healthy, viable statewide educator-user groups. We were looking to find out how many members they had, and how many years they'd been around. We asked how they were funded, and whether they were affiliated with any nationwide group. We wondered what sorts of services they offered their members. And we asked them to describe the level of interest in computing among educators in their state.

Very few of the educators we talked to had figures they felt were current and reliable. Instead, they used words like "geometric" and "exponential" to describe the growth rate of computer use in their state's schools. Some only reluctantly gave us the results of quite recent polls, saying they knew those figures were already woefully out of date.

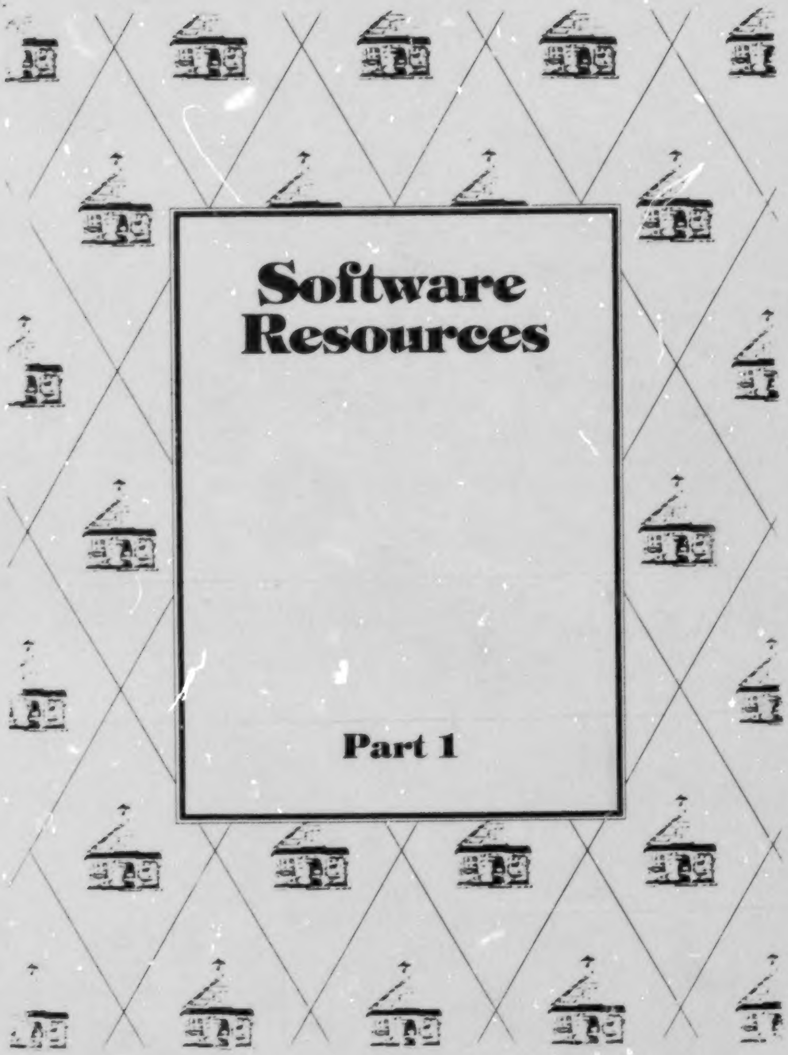
But that lack of statistics only makes their message—and the upshot of this survey—that much clearer: despite widespread problems of funding and inexperience, interest *at the local level* in using computers in schools is growing faster than anybody can measure it.

The particulars of *EL*'s Survey results are presented in the charts on pages 64-71. Herewith, a brief summary of our findings:

- The survey turned up as many as 38 statewide educator-user groups in 33 states, all of which have the general aim of promoting the effective use of computers in the classroom. In those states where no statewide groups were identified, most often a special arm within the state department of education (DOE) was filling that role.
- Organizing conferences, acting as general resource centers, and publishing newsletters were the most prevalent activities of the user groups. Around two-thirds of the groups were involved with teacher training programs; smaller numbers had set up software lending libraries or evaluation procedures. Only a few had helped arrange cooperative purchasing ventures between districts seeking a price break on equipment.
- Almost all of the groups were funded through membership dues, ranging from $2/year on up to $25.
- One-third of the groups were affiliated with the International Council for Computers in Education (ICCE); another third with the Association for Educational Data Systems (AEDS); ten were offshoots from their state DOE, and only three were unaffiliated.
- While a handful of groups dated back into the 1960s, most were formed quite recently; six, in fact, had come into being over the past 12 months. At this writing, seven other states were gearing up to form their own groups.

But if there's one thing we learned from completing this survey—it's that that figure is undoubtedly already out of date.

BEST COP



Software Resources

Part 1

Software Resources

Table of Contents

Clearinghouses Page 12

These organizations disseminate information about and critiques of commercially developed educational software. They also provide access to public domain programs. (Similar services are available from many of the local and regional resource centers located in the State-by-State Listing in Part 4.)

Review Sources Page 13

Devoted solely to reviewing software, these publications can be ordered directly from the addresses provided. (Also see Educational Computing Magazines in Part 3; many publish software reviews.)

Directories Page 13

The publications included in this section list software packages available for use on major educational computer systems. Many of the directories are organized by subject area, and some are computer specific.

Publishers Page 15

This comprehensive listing contains the addresses and phone numbers of more than 500 educational software publishers.

Distributors Page 41

The 85 major educational software distributors listed here provide schools with catalogs that describe the numerous software product lines available through mail order or sales representatives.

Clearinghouses

Compukids Computer Courseware Lending Library
Rossmoor Center
12385 Seal Beach Blvd
Seal Beach, CA 90740
(213) 430-7226

Subscribers to this service can rent educational software in the areas of reading, language arts, math, cognitive skills and other academically oriented categories. Programs are for Apple computers. Membership fee is $50.00, with a $1.00-$2.00 per-program rental fee.

Conduit
P.O. Box O
Oakdale, IA 52319
(319) 353-5789

Conduit both reviews and distributes software, primarily for secondary and higher education. Conduit has a project to convert mainframe and minicomputer programs for use on microcomputers. Its *Authors Guide* has been used as a model for establishing guidelines for developing and evaluating software. Conduit's magazine, *Pipeline*, is published twice a year (see Information Sources for Adults: Computing Magazines).

Microcomputer Resource Center
Teachers College, Columbia University
525 W. 121st. St.
New York, NY 10027
(212) 678-3740

The microcomputer resource center at Teachers College (see State-by-State Listing: New York) functions as a software evaluation and demonstration facility. Area educators and administrators can attend workshops and seminars pertaining to software and other curriculum materials.

Microcomputer Software and Information for Teachers (MicroSIFT)
Northwest Regional
Educational Laboratory
300 S.W. Sixth Ave.
Portland, OR 97204
(503) 248-6800

MicroSIFT serves as a clearinghouse for information on instructional and administrative applications of software. Funded by the National Institute of Education, its key objectives include the development of evaluation models, the implementation of a technical assistance program in the northwest, and the dissemination of information on available courseware and related materials. MicroSIFT's evaluation data is contained in a computer database called Resources in Computer Education (RICE), which can be reached through the Bibliographic Retrieval Service (see Information Sources for Adults: On-line Sources).

Sofsearch
2973 E. Coronado
Anaheim, CA 92806
(714) 632-6671

Sofsearch is a software locator service that uses a constantly updated database of information obtained from thousands of software vendors. A subscription to Sofsearch includes five regular search reports containing information about software products that meet subscriber specifications. Reports are updated quarterly and additional searches are available at reduced rates. Annual subscription fee is $175.00; nonsubscribers pay $60.00 per single search report.

Softswap
San Mateo County Office of Education
333 Main St.
Redwood City, CA 94063
(415) 363-5472

Softswap is both a clearinghouse for information on educational software and a software exchange facility. Educators who live in the county can come to the microcomputer center of the San Mateo Educational Resource Center (see State-by-State Listing: California) and copy any of the more than 300 public domain programs, or exchange an original program on disk for a Softswap disk. The programs maintained at the center are evaluated and refined before distribution. Programs are available for a wide variety of machines.

Ye Olde Apple Orchard
Mankato State University
Memorial Library
Educational Resource Center
Mankato, MN 56001
(507) 389-6201

Used by public and private schools in 47 school districts in southern Minnesota, this software lending library gives students access to educational software and 25 Apple II microcomputers. Commercial software is solicited from publishers for preview and examination only. Students using the center include those from the university as well as periodic visits by groups of primary school children. Ye Olde Apple Orchard also sponsors research into educational computing applications.

Review Sources

Courseware Report Card
Educational Insights
150 W. Carob St.
Compton, CA 90220
(213) 979-1955
Price range: $22.50-$95.00

Separate issues are published for Apple, Atari, CBM, PET and TRS-80 computers, as well as for elementary and secondary levels. Every issue contains both evaluations and summaries.

Courseware Reviews 1982
SMERC Library Microcomputer Center
San Mateo County Office of Education
333 Main St.
Redwood City, CA 94063
(415) 363-5472
$10.00

Fifty programs in all curriculum areas are evaluated in this publication. The reviews are compiled by educators throughout California. Besides describing each program, the reviews include noted strengths, weaknesses and student responses, plus a checklist of evaluation criteria. Wherever applicable, they also list publications that have published critical reviews of the programs.

The Digest of Software Reviews: Education
Ann Lathrop, Editor
School and Home Courseware, Inc.
Suite C
1341 Bulldog Ln.
Fresno, CA 93710
(209) 227-4341
$10.00/issue, $42.95/4 issues (prepaid)

The *Digest* profiles instructional software programs, including administrative programs for the Apple, Atari, Comodore, IBM, TI and TRS-80 microcomputers. Each issue reviews 50 programs, drawing from those programs reviewed most often in more than 60 journals, newsletters and other review sources.

Media Review
172 Holmes Rd.
P.O. Box 425
Ridgefield, CT 06877
(203) 438-2843
K-8: $69.00/12 issues
9-college: $69.00/12 issues
K-college: $99.00/12 issues

Each issue of this monthly publication includes microcomputer software evaluations covering a specific subject area (science, math, social studies, etc.). Reviews are composites of several evaluations, at least one of which is the result of classroom field-testing. Program reviews are cumulatively indexed by title, publisher and subject. Three editions of *Media Review* are available.

Micro-Courseware/Hardware/Pro/Files and Evaluations
EPIE Institute
P.O. Box 839
Water Mill, NY 11976
(516) 283-4922
$260.00/260 profiles (must be purchased as set)

Pro/Files are two- to four-page software evaluations covering all major curriculum areas and grade levels. The purchase of this evaluation product includes a file box with courseware reviews divided into various subject areas. Typical review information includes analyst's summary, capsule evaluation, user comments, sample frames, students' comments, other reviews of the program, how the teacher and students use the program, instructional/educational value, and documentation evaluation. Subscription price includes biannual updates to the files and the *MICROgram* newsletter, published nine times a year.

Peelings II, The Magazine of Apple Software and Hardware Evaluation
P.O. Box 188
Las Cruces, NM 88004
(505) 526-8364
$3.00/issue, $21.00/9 issues

Peelings II rates products from AAA (absolutely astounding software) to F (unacceptable). Ratings are based on price, performance, documentation, ease of use and sophistication. Educational software as well as utilities and data management systems are reviewed regularly.

Software Report Cards
InfoWorld
530 Lytton Ave.
Palo Alto, CA 94301
(415) 328-4602
(800) 343-6474
$3.95/issue (published quarterly)

Software reviews from the weekly publication *InfoWorld* (see Information Sources for Adults: Computing Magazines) are collected in this publication and sent free of charge to *InfoWorld* subscribers. Approximately 20 percent of the software reviewed is specifically educational, and much of the rest is of interest to administrators and home computer users.

Directories

The Addison-Wesley Book of Apple Computer Software
Continental Software
11223 S. Hindry Ave.
Los Angeles, CA 90045
(213) 417-8031
$19.95

Extensive descriptions of educational

(continued)

Directories
(continued)

courseware packages are included in this directory of Apple-compatible software. A numerical rating, based on such criteria as ease of use and error handling, accompanies each entry.

The Addison-Wesley Book of Atari Software
Continental Software
1223 S. Hindry Ave.
Los Angeles, CA 90045
(213) 417-8031
$19.95

Approximately 50 educational software programs, graded on overall value, vendor support, ease of use, reliability and attractiveness, are included in this directory.

The Blue Book
WIDL Video Publications
5245 W. Diversey Ave.
Chicago, IL 60639
(312) 622-9606
Apple and IBM editions, $24.95
Atari and Commodore editions, $17.95

The Blue Book is published separately for the Apple, Atari, Commodore and IBM computers, and includes product listings for software, hardware and accessories. *The Blue Book* is distributed as a reference book to schools, colleges and public libraries.

Commodore Software Encyclopedia
Commodore International
Computer Systems Div.
1200 Wilson Dr.
West Chester, PA 19380
(215) 431-9100
$9.95

Nearly 2,000 software packages for use on Commodore computers are described in this directory, which includes lists of vendors, user groups and dealers.

Educational Software Directory: A Subject Guide to Microcomputer Software
Libraries Unlimited
P.O. Box 263
Littleton, CO 80160
(303) 770-1220
$22.50

This directory includes complete descriptive information on over 900 educational microcomputer software packages for grades K-12. Each entry includes the name of the software package, publisher, grade level, format, language, price and a lengthy annotation. There is also a publisher and distributor index.

Educational Sourcedisk
Educational Associates
P.O. Box 3522
Phoenix, AZ 85069
(602) 869-9223
$79.95

This electronic software directory is a combination database and word processing program. More than 200 software publishers are listed, providing materials for Apple, Atari, Commodore, IBM and Radio Shack. Selections can be made by grade level, curriculum area and computer. A letter-writing capability allows direct inquiry and automatic addressing. The directory runs on the Apple. Free backup is provided and inexpensive updates are available.

Hewlett-Packard Series 80 Software Catalog
Series 80 Users' Library
1010 N.E. Circle Blvd.
Corvallis, OR 97330
(503) 757-2000
$12.95

This reference guide to all software available for Series 80 Personal Computers contains both contributed programs and Hewlett-Packard packages. A section on educational software is included.

Index to Computer Based Learning
Educational Communications Div.
University of Wisconsin
P.O. Box 413
Milwaukee, WI 53201
(414) 963-5478
$48.00/4 volumes, $15.00/microfiche

More than 4,800 computer-based learning programs are cross-referenced by source, programming category, central processor type and programming language.

International Directory of Software Computing Publications, Inc.
Princeton Forrestal Center
101 College Rd. East
Princeton, NJ 08540
(609) 452-8090
$195.00

Software packages in this directory are organized into 107 different categories and indexed by industry, function and title. Quarterly updates on new product developments are available for an additional $45.00.

Microcomputer Software Directory
Computing Publications
101 College Rd. East
Princeton, NJ 08540
(609) 452-8090
$120.00

This directory lists more than 7,500 software programs in the areas of education, entertainment and business.

Micro-Software Guide and Directory
OnLine, Inc.
11 Tannery Ln.
Weston, CT 06883
(203) 227-8466
$40.00, $30.00 for annual supplements

This guide describes over 700 software packages listed in the index by producer, application, distributor and package name. Also included are an annotated bibliography, industry resource section, glossary, and articles about buying and using software.

The Microsource
Goddard and Case Publishers, Inc.
108 Oregon Ave.
Bronxville, NY 10708
(914) 779-8869
Free

This innovative software directory includes all types of applications software listings—games, educational, home/personal, math/statistics, business and professional.

1984 Microcomputer Marketplace
Dekotek, Inc.
2248 Broadway
New York, NY 10024
(212) 799-6602
$75.00 ($59.00 before 12/31/83)

This directory includes background data for software publishers and distributors, and listings of suppliers and manufacturers. Also included are listings of microcomputer associations, magazines, newsletters, producers, developers, consultants, and a calendar of events and meetings.

PC Clearinghouse Software Directory
PC Clearinghouse, Inc.
11781 Lee Jackson Hwy.
Fairfax, VA 22033
(703) 352-0721
$29.95 plus shipping

More than 21,000 software packages for over 200 microcomputers, cross-referenced by operating system and compatible hardware, are listed in this directory.

Radio Shack TRS-80 Educational Software Sourcebook
Available from Radio Shack Stores
$4.95

More than 1,200 software packages for all TRS-80 model computers are organized by instructional techniques, user level, subject category, computer model and publisher in this directory, which will be available in September 1983.

Skarbek Software Directory
Skarbek Corporation, Inc.
1531 Sugargrove Ct.
Saint Louis, MO 63141
(314) 567-7180
$9.95

This directory lists more than 1,000 programs for Apple microcomputers. Educational software includes student programs, and administrative and utility packages. Programs are listed alphabetically by title and are indexed by subject.

The Software Catalog
Elsevier Science Publishing Co., Inc.
52 Vanderbilt Ave.
New York, NY 10017
(212) 867-9040
[illegible]

More than 15,000 [illegible]s are included in this directory, which covers a wide range of interests including education, games, professional applications, systems software and utilities. An updated supplement of 2,500 additional programs is available for $15.00.

The Software Finder: A Guide to Educational Microcomputer Software
Dresden Associates
P.O. Box 246
Dresden, ME 04342
(207) 737-4466
$25.00/year

Formerly the *School MicroWare Directory*, the *Software Finder* is published twice a year and includes educational software of all types, subject areas and grade levels (through college). It is organized by subject area and includes a hardware-specific index.

The SpecialWare Directory
LINC
Suite 225
1875 Morse Rd.
Columbus, OH 43229
(614) 263-2123
$10.00

Complete information about microcomputer software for use in special education is included in this directory, which also lists instructional, administrative, professional and evaluation/testing materials.

Swift's 1983-84 Educational Software Directory, Apple II Edition
Sterling Swift Publishing Co.
7901 S. IH-35
Austin, TX 78744
(512) 282-6840
$18.95

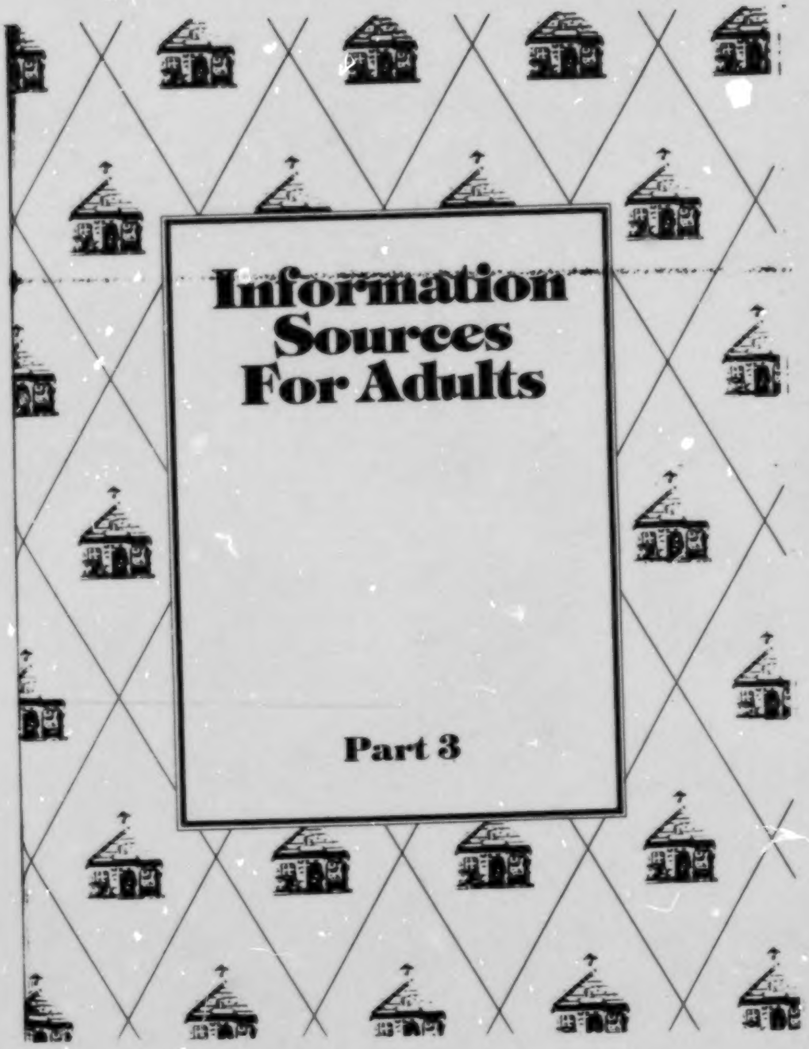
Hundreds of educational software programs for the Apple II are organized by subject area in this directory, which also includes a description of each program, a publisher's information section and a master index.

TI-99/4A Software Directory
Texas Instruments, Inc.
P.O. Box 53
Lubbock, TX 79408
(800) 858-4565
$5.95

This 1983 directory lists all of the software currently available for the TI-99/4 and TI-99/4A computers, and includes all diskette, cassette and solid state cartridges from both TI and third-party authors.

Vanloves Apple II/III Software Directory
Advanced Software Technology
P.O. Box 2038
Shawnee Mission, KS 66202
(913) 648-4412

Programs are listed alphabetically and by subject area in this Apple software directory, which includes an educational courseware section.



Information Sources For Adults

Part 3

Information Sources For Adults

Table of Contents

Books Page 82

The 42 nonfiction books described here supply a full range of educational computing information, from how to write your first program to curriculum suggestions for K-12 classrooms. Publishers' addresses and phone numbers are listed at the end of the section.

- Book Publishers Page 84

Magazines

- Educational Computing Page 85

Written especially for computer-using educators, these magazines feature classroom-focused articles, software reviews and new-product news. Subscription information and single-issue prices are included with each listing; an asterisk indicates that the publication is not available on the newsstand.

- Computing
  - —General Page 87

Although the 16 magazines listed here are written for computer enthusiasts in general, they contain a broad range of information relevant to educators. Many of the publications also have monthly departments covering educational computing issues and products.

  - —Computer Specific Page 88

Each of these magazines is written for users of a particular computer system. All of the publications contain new product information, and ideas about home and school applications.

Newsletters

- Educational Computing Page 90

Most of these newsletters are published by organizations involved in classroom computing. Publications report on findings from current studies and provide coverage of conferences; many contain programs and programming tips.

- Computing Page 91

The newsletters described here provide information about computer-related topics from product news to user groups. Many of the publications are computer specific.

On-line Sources Page 92

The four on-line information and search services described here provide access to all major education-related databases. Write or call for subscription information and a list of the databases accessible through these sources.

Database Directories Page 92

These directories provide detailed information about the thousands of databases available and how to conduct an on-line search for a specific subject.

Magazines

Educational Computing

AEDS Journal* and **AEDS Monitor***
Association for Educational
Data Systems
1201 16th St., N.W.
Washington, DC 20036
(202) 822-7845
Journal: $7.00/copy; $32.00/4 issues
Monitor: $5.00/copy; $28.00/6 issues

The *AEDS Journal* is a professional/academic quarterly that publishes reports on original research, project descriptions and evaluations, as well as theories relating to educational computer use. Many articles focus on problems in instructional design and administrative applications, and are prefaced by an abstract and a list of keywords. The *AEDS Monitor* reports bimonthly on research and applications of computers in education. Research and reviews from other groups, such as ERIC and MECC (see Educational Computing Organizations: National Associations), are regularly included.

Classroom Computer Learning*
Pitman Learning, Inc.
19 Davis Dr.
Belmont, CA 94002
(415) 592-7810
$2.50/issue; $19.95/9 issues

Classroom Computer Learning, formerly *Classroom Computer News*, links computer-based learning with traditional classroom instruction. Published nine times during the school year, the magazine includes: teacher-developed classroom ideas, articles with original programs, software reviews, and a pullout poster for classroom use. Manufacturers' information on new products and a calendar of events in the educational computing world also appear in each issue. Two of the issues are directories; one lists educational computer resources and the other covers educational software.

Computers in the Classroom*
3 Carlaw Ave.
Toronto, Ontario
Canada M4M 2R6
(416) 461-9206
$2.50/issue; $25.00/10 issues

Each subscription to this Canadian publication includes a copy of the *Canadian Educational Courseware Software Directory & Daily Journal*. *Computers in the Classroom* includes book and software reviews, a question and answer column, and articles on such subjects as computer languages.

The Computing Teacher*
International Council for Computers in Education (ICCE)
University of Oregon
1787 Agate St.
Eugene, OR 97403
(503) 686-4429
$3.00/issue; $16.50/9 issues

The Computing Teacher publishes general and technical articles on the instructional uses of computers and on teaching about computers. Offered to members of the International Council for Computers in Education (see Educational Computing Organizations: National Associations), it emphasizes precollege education and teacher training. Teachers in the field write most of the articles. It also includes programming suggestions; computing problems; software and book

(continued)

Magazines: Educational Computing
(continued)

reviews, news items on conferences, projects and resource centers, and technological developments in computers. Occasionally mentions uses of calculators in education.

CRLA*
P.O. Box 13247
Oakland, CA 94661
(415) 495-7607
$4.00/issue; $14.00/4 issues (individuals); $18.00/4 issues (schools, libraries and other institutions)

CRLA: Computers, Reading and Language Arts is a new quarterly for educators. Articles describe educators' firsthand experiences with innovative approaches, overviews of how computers can amplify teaching skills, research on new approaches for dealing with fundamental educational issues, and practical suggestions for evaluating software.

Educational Computer Magazine
Edcomp, Inc.
P.O. Box 535
Cupertino, CA 95015
(408) 252-3224
$3.00/issue; $15.00/10 issues

This magazine for educators using computers in the classroom examines possible benefits and problems of instructional computing. Each issue includes regular columns, book and educational software reviews, an advice column, and a calendar of upcoming conferences in the field. Articles cover such topics as teacher in-service, Logo and courseware evaluation.

Educational Technology*
140 Sylvan Ave.
Englewood Cliffs, NJ 07632
(201) 871-4007
$6.00/issue; $49.00/12 issues

This long-established monthly is oriented toward general educational use of technology. Each issue has columns on educational computing and relevant media news. Periodic special issues offer a collection of articles examining specific facets of classroom use of technology, including detailed reviews of books, materials and products. *Educational Technology* draws attention to worthwhile commercially available courseware. Columnists comment on specific developments in educational technology, theoretical articles discuss the whys of educational computer applications.

Electronic Education
Electronic Communications, Inc.
Suite 220
1311 Executive Center Dr.
Tallahassee, FL 32301
(904) 878-4178
$3.00/issue; $18.00/9 issues

Electronic Education informs school administrators and educators from middle school through college about the uses of technology in education. Articles cover technology's applications in schools, new products, trends and interviews with prominent people in the field.

Electronic Learning
Scholastic, Inc.
730 Broadway
New York, NY 10003
(212) 505-3000
$3.50/issue; $19.00/8 issues

Electronic Learning provides nontechnical introductions to educational computing applications. News columns—including a Washington report and international items—report on innovations and official receptivity to computers in education. A group of educators evaluates commercial software, and discusses the success of classroom applications as well as pedagogical and programming faults in the software. Regular features include a primer for teachers with minimal computer literacy, teachers' suggestions for simple computer-based classroom activities, and guides to proposal writing and funding sources for the purchase of educational technology.

Instructional Innovator*
AECT
1126 16th St., N.W.
Washington, DC 20036
(202) 466-4780
$3.00/issue; $24.00/8 issues

Published by the Association for Educational Communications and Technology (AECT), *Instructional Innovator* features articles on new aspects of educational technology. Free to AECT (see Educational Computing Organizations: National Associations) members, it monitors educational computing and offers special issues on microcomputers in education. Articles and a new products section regularly describe hardware. Also announces bibliographic searches and reports available from the ERIC database.

Interface*
915 River St.
Santa Cruz, CA 95060
(408) 425-3851
$4.00/issue; $12.00/4 issues

For computer science and data processing educators, *Interface: The Computer Education Quarterly* includes book reviews and programming tips. Articles and opinions discuss curricula and methodologies involved in teaching about computers.

Journal of Computer-Based Instruction*
ADCIS
Western Washington University
409 Miller Hall
Bellingham, WA 98225
(206) 676-3000
$6.50/issue; $36.00/4 issues

Free to members of the Association for the Development of Computer-Based Instructional Systems (see Educational Computing Organizations: National Associations), the *Journal* is a professional quarterly of theoretical articles, lectures and reports. Writings discuss research findings and surveys in the field of computer-based instruction in elementary and secondary school systems, colleges, business, military and government agencies.

Journal of Educational Technology Systems*
Baywood Publishing Co., Inc.
Box D
120 Marine St.
Farmingdale, NY 11735
(516) 249-7130
$56.00/4 issues

This quarterly technical educational journal is primarily concerned with curriculum and program development. Articles discuss the models and structure inherent in educational programs, and are directed toward the developers of curriculum projects or instructional support systems.

The Logo and Educational Computing Journal*
Suite 219
1320 Stony Brook Rd.
Stony Brook, NY 11790
(516) 751-5139
$20.00/5 issues

Targeted at teachers currently using microcomputers in their classrooms, this magazine focuses on versions of the Logo language. The editors welcome readers' research findings and commentary on computer-assisted instruction and related issues.

Pipeline*
P.O. Box 388
Iowa City, IA 52244
(319) 353-5789
$3.50/issue; $10.00/12 issues

Published twice yearly by Conduit (see Software Resources: Clearinghouses), *Pipeline* offers ideas for computer use in education. Each issue contains descriptions of and order forms for Conduit's latest reviewed and tested materials, some of which are applicable to secondary schools. Articles integrate discussions of educational technology, pedagogy and curriculum content.

School Microcomputer Bulletin*
Learning Publications, Inc.
c/o Bock Marketing Services
3030 S. Ninth St.
Kalamazoo, MI 49007
(616) 372-1045
$28.00/10 issues; $50.00/20 issues (2 years)

In its second year of publication, *SMB* explores computing concepts and trends, and is written specifically for educators

Teaching and Computers
Scholastic, Inc.
730 Broadway
New York, NY 10003
(212) 505-3000
$3.50/issue; $15.95/8 issues (introductory), $19.00/8 issues (regular)

Geared to elementary school teachers, *Teaching and Computers* provides information and practical suggestions for integrating computers into the classroom. It includes nontechnical information about how computers work, teacher-developed lesson ideas, and informative new books and resources.

T.H.E. Journal
P.O. Box 17239
Irvine, CA 92713
(714) 261-0366
Free to qualified schools and organizations

Published eight times a year, *Technological Horizons in Education (T.H.E.) Journal* discusses the theoretical and practical aspects of education technology. Reviews of software, projects and publications are linked to an Inquiry Service Card so that readers can get additional information from manufacturers. Material is geared toward the promotion of educational technology.

Newsletters

Educational Computing

ACM SIGCUE Bulletin
Computer Uses in Education
Assoc. for Computing Machinery
11 W. 42nd St.
New York, NY 10036
(212) 869-7440
$4.00/issue; $20.00/4 issues (half price for ACM members)

The *Bulletin* contains a wide range of articles, reviews and information resources useful for educators interested in computers. Practical guides to preparation of computer-based instructional materials and reports of research on the educational value of computer-aided instruction are often included. The *Bulletin* presents interviews with leaders in educational computing and provides coverage of conferences and current projects in this field. Published by the Association for Computing Machinery (see Educational Computing Organizations: National Associations).

Computers in Education
Studebaker Technology
189 Newton
Glen Ellyn, IL 60137
(312) 858-7869
$1.50/issue; $18.00/12 issues

This monthly newsletter focuses on the process of selecting, acquiring and using computers in schools, and includes information about funding, software, research and support materials.

Computer Time
Robert Stuart Computer Club
Robert Stuart Junior High
644 Caswell Ave. West
Twin Falls, ID 83301
(208) 733-4875
$3.00/6 issues

Computer Time is produced by students and educators in the Stuart School in Idaho (see State-by-State Listing: Idaho). Dedicated to the growth of computer programming in schools, *Computer Time* contains programs, helpful programming hints, and notices of computing resources and publications.

C.U.E. Newsletter
Box 18547
San Jose, CA 95158
(408) 288-7642
$8.00, individuals; $20.00, institutions/6 issues (includes membership)

The California-based group Computer Using Educators (see State-by-State Listing: California) publishes this bimonthly newsletter that contains material of interest to computer educators. Announcements, letters, opinions, programs, teaching ideas and curricula, and software or hardware reviews are contributed by members. Information on upcoming conferences is also included.

ERIC/IR Update
Syracuse University
ERIC Clearinghouse on
Information Resources
School of Education
Syracuse, NY 13210
(315) 423-3640
Free/2 issues

This semiannual bulletin reviews selected microcomputer-related items from the ERIC microfiche collection, as well as books available from commercial publishers.

ETC
Far West Laboratory
1855 Folsom St.
San Francisco, CA 94103
(415) 565-3221
$27.00/11 issues

The *Educational Technology & Communication (ETC)* newsletter is published monthly by the Far West Laboratory for Educational Research and Development (see Educational Computing Organizations: National Resource Centers). *ETC* includes information about computing resources, upcoming conferences and new publications. Describes classroom applications of computers and runs a column answering readers' questions.

Hands On!
Technical Education Research
Centers
8 Eliot St.
Cambridge, MA 02138
(617) 547-3890
$10.00/4 issues

Each issue contains programs, book and software reviews, news on conferences and an idea exchange forum. Two new columns are called "Classroom Computing" and "Tools of the Trade." *Hands On!* is published four times a year by TERC (see Educational Computing Organizations: National Resource Centers).

Microcomputers in Education
Queue, Inc.
5 Chapel Hill Dr.
Fairfield, CT 06432
(203) 335-0908
$38.00/12 issues

Queue, a software distributor, publishes this monthly newsletter, which focuses on the commercial educational software marketplace. Besides describing new educational programs available from Queue, the newsletter summarizes software reviews from other magazines and notes where the reviews first appeared. *Microcomputers in Education* regularly carries announcements of new products, publications, workshops and projects. Subscribers receive a 10-percent discount and 30-day return priviledges on all software ordered from Queue.

National Educational Computer Review
National Educational
Computer Library (NECOL)
P.O. Box 293
New Milford, CT 06776

(203) 354-7760
$12.00/5 issues

This newsletter published by NECOL (see Educational Computing Organizations: National Resource Centers) reports on conferences and new trends in educational computing, and reviews books, periodicals and software.

Newsletter of the Consortium on Uses of Computers in Mathematical Sciences Education
Math Sciences Dept.
14 Memorial Hall
University of Delaware
Newark, DE 19711
(302) 738-2140

Available free from the Consortium on the Uses of Computers in Mathematical Sciences Education (see State-by-State Listing: Delaware), this newsletter is intended for educators at all levels, elementary through postsecondary.

Computing

Apple Education News
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010
Free/4 issues

Apple Education News, a quarterly publication of Apple Computer, Inc., contains industry updates, product descriptions, educational computing news and feature stories about the use of Apple computers in schools around the world.

Apple Orchard
P.O. Box 2227
Seattle, WA 98111
(415) 878-9171
$10.00/4 issues

A quarterly newsletter published by the International Apple Core (see Educational Computing Organizations: National User Groups), *Apple Orchard* contains utility programs, news about products for the Apple, interviews and programming tips.

Atari Teacher's Network Newsletter
c/o Nancy Austin Shuller
P.O. Box 1176
Orange, NJ 07051
(201) 763-1317

This newsletter is published by the Atari Teacher's Network (see Educational Computing Organizations: National Associations) and others interested in sharing information on use of the Atari computer in the elementary classroom. Network membership is $4.00 annually and includes the quarterly newsletter.

BuSS
716 E. Street, S.E.
Washington, DC 20003
(202) 544-0900
$20.00/12 issues, $32.00/24 issues

BuSS provides short articles and programming tips for Heath/Zenith users. It is published about every three weeks.

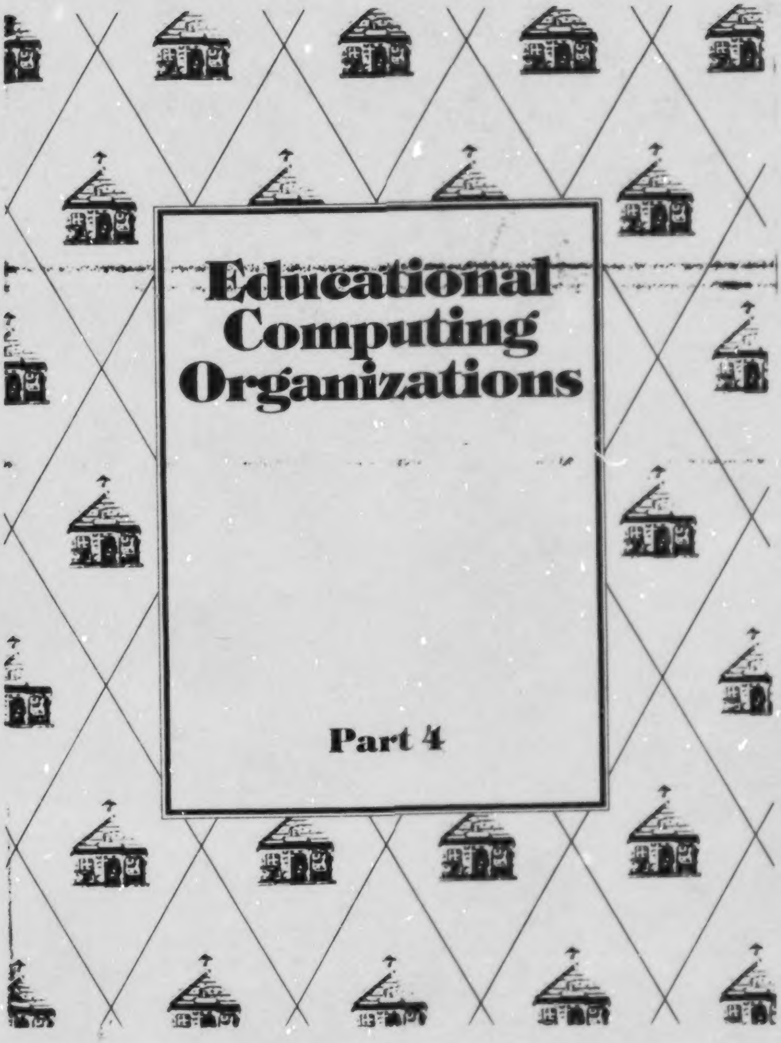
FOLLK-Lore
Friends of LISP/Logo & Kids
436 Arallo Dr.
San Francisco, CA 94132
(415) 75F-OLLK
$7.50/one year (published irregularly)

Published by Friends of LISP/Logo & Kids (see State-by-State Listing: California) to disseminate information about artificial intelligence. Ideas for using Logo in the classroom, problems and puzzles for children, and discussions of new computers appear in each issue.

Library Systems Newsletter
American Library Assoc.
50 E. Huron St.
Chicago, IL 60611
(312) 944-6780
$30.00/12 issues

This newsletter is published monthly by Library Technology Reports. It reports

(continued)



Educational Computing Organizations

Part 4

Educational Computing Organizations

Table of Contents

National Organizations

• Associations Page 94

These groups provide members the opportunity to exchange ideas and information through meetings and publications. Many of the associations have state affiliates (see State-by-State Listing below).

• Resource Centers Page 96

Centers vary widely in the services they offer educators, and may include information referrals, software exchanges and public access terminals.

• User Groups Page 98

These organizations of computer users exchange ideas and advice. Most groups are computer specific; many have education special interest groups.

• User-Group Clearinghouses Page 98

The national offices listed here provide individuals with information about local user groups.

State-by-State Listing . . . Page 99

. . . Education Departments

Each state listing begins with the name, address and telephone number of the individual responsible for disseminating information about educational computing.

. . . Associations

These organizations provide educators the opportunity to exchange information about computer use in the schools through publications and regular meetings.

. . . Resource Centers

The centers listed under this heading offer educators and the general public a variety of services, including hands-on computer experience, software previewing, and consultation about the selection of computers for the classroom.

Canadian Organizations

• Education Departments Page 120

Listed here are the individuals responsible for disseminating information about educational computing activities within their provinces or territories.

• Associations Page 120

These groups provide area educators the opportunity to exchange ideas and information through regular meetings, publications and special reports.

• Resource Centers Page 124

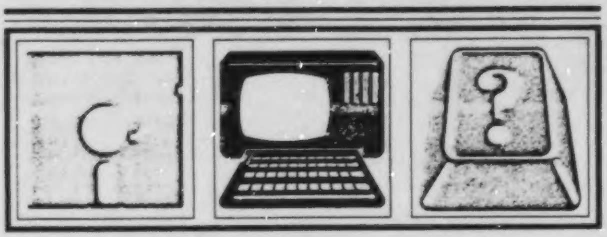
Offering workshops, software information and hands-on computer experience, these centers promote computer literacy within the province.

BEST COPY

1983

Classroom Computer News

DIRECTORY



OF EDUCATIONAL COMPUTING RESOURCES

PART I

Sources: People, Places and Things

Table of Contents

Ideas, Information, and Materials

Anthologies 16
Bibiliographies 17
Indexes 17
Online Sources and Databases 18
Databases 18
Resource Centers 20
Research and Development 22

Software

Software Directories 27
Software Reviews 30
Software Clearinghouses ... 32

Associations

Educational Technology 35
Computing Science 36
Educational 36

Periodicals

Educational Computing 38
Computing 43
Educational 44
Newsletters 44
Funding 46
Miscellaneous Resources 48

Ideas, Information, and Materials

Information on computers can be obtained in almost as many ways as computers can be used. This section provides descriptions of a variety of information resources. For print resources, see Anthologies, Bibliographies, and Indexes. Sources of computer-based information retrieval are described in Online Sources and Databases (from personal computer bulletin boards to complex data and reference systems). For human resources consult the listings under Resource Centers (groups, places, and services assisting educators with educational computing information, training, and planning) and Research and Development. While the Research and Development organizations also occasionally provide direct training or advisory services to educators, the main reason for including them is simply to identify those group currently contributing to advances in educational computing.

PART II

53

Computer-Specific Resources

The growth of educational applications of computers over the last few years has been remark Because many schools are committed to one, or at most two, types of computer, it is possible for t to narrow their search to sources of information, ideas, and materials for just their brand of c puters. To help educators focus their search, this part of the *1983 Directory* lists resource periodicals, software directories, and user groups — for each type of microcomputer system use instructional and educational administration applications.

The sources listed do not include those for minicomputer or mainframe systems simply beca at this time, there are few publications or user groups for these systems. However, users of Hewl Packard and minicomputer systems or DEC minicomputer system or CDC's PLATO system will f some resources for these systems elsewhere in the *Directory* by using the Index.

The periodicals and magazines listed below for each computer system are invaluable source new product information, software reviews, and programming tips. In addition, more gene magazines such as *Compute!* and *Micro* have lengthy computer-specific sections.

This is not a software directory. There are no descriptions of software *per se*. Instead, we ha described various software directories which themselves contain listings of software for particul machines. Also, some software catalogues and a number of individual programs may be fou advertised in the Yellow Pages of the *1983 Directory*.

Finally, the user groups listed in this part are not necessarily educationally oriented. Howeve these groups facilitate the sharing of programming tips and hardware information that are of intere to the computer-using educator as well as to the hobbyist and business person.

PART III

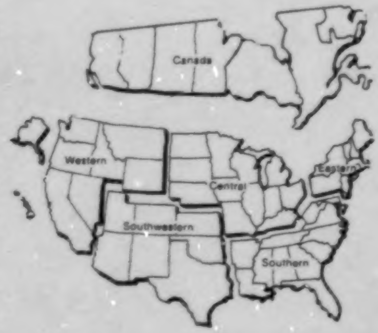
91

Local and Regional Resources

The most useful resources for educators interested in computing may be those available in their immediate geographical area. This part of the Directory is intended to facilitate the sharing of information and ideas among computer-using educators in the same region.

Within the sections for each U.S. state and each Canadian province we list government contact persons who have been designated to deal with educational computing. Also listed are CCN contact persons who have agreed to refer educators to computing resources available and to help answer queries. While these contact persons welcome calls during the weekday hours listed, they ask that inquiries by mail be accompanied by a self-addressed stamped envelope and that questions over the phone be brief and specific.

The bulk of the listings for each state and province are places and organizations. Educators should find Resource Centers, Ongoing Projects, and Organizations to be particularly useful. Teachers, parents, and children should find Computer Learning Places, and User Groups to be a source of interest and learning about computers.



The market is already very crowded, with a large number of diverse competitors.

SCHOOL EDUCATIONAL SOFTWARE:
SELECTED COMPETITORS

Types of competitors	Examples
Educational publishers	- SFN - Mindscape - Scholastic - Wizware - CEPP/CSW - Milliken - Addison Wesley - McGraw-Hill
Hardware manufacturers	- IBM - Apple - Commodore
Educational software publishers	- Spinnaker - EduWare (MSA/Peachtree) - The Learning Company
Nonprofit agencies	- Minnesota Educational Computer Consortium (MECC) - CONDUIT
System/professional application software publishers	- Visicorp - Microsoft
Video game producers	- Atari - Milton Bradley

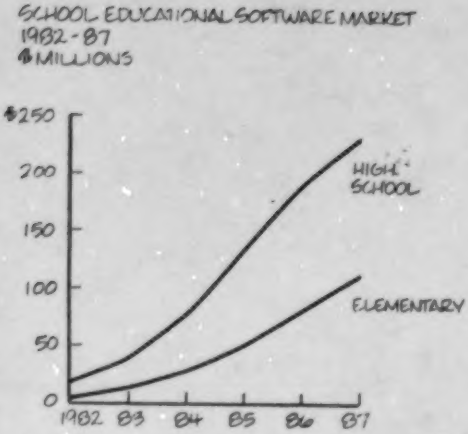
CAI educational programs cover a wide range of school subject areas . . .

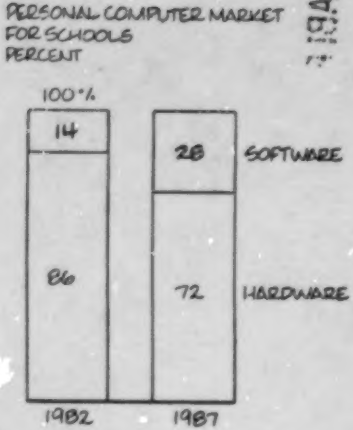
MICROCOMPUTER PROGRAMS BY SUBJECT

Subject area	Number of programs
Language Arts	1,627
Math	537
Science	234
Social Studies	175
Educational Games	96
SAT Preparation	53
Library Science	38
Others	203
Total programs	2,963

Source: Future Computing (December 1982)

The market for school educational software is expected to grow rapidly . . .





SOURCE: FUTURE COMPUTING; McKINSEY

Market Status and Prospects: School

The school market has demonstrated potential for CAI applications but is still an emerging one.

Evaluation criteria	Current situation
- Hardware penetration	- Estimated 70% of 80,000 U.S. schools have one or more microcomputers; a total of 350,000 in all
- Applications/ demand	- Broad and growing range of software applications available - Over 3,000 school educational software programs available from large number of sources/publishers
- Market prospects	- Educational trends/funding and hardware manufacturers are supporting growth in hardware penetration - Precise role of CAI in teaching and learning still to be defined - Competition already intense - Software distribution issues (e.g., configuration/networking, relationship with home market, bundling/pricing) still unresolved

Data From Swift's Educational Directory for the Apple*

Year	# Publishers Listed	# Titles Listed
81-82	100	800
82-83	140	1201
83-84	236	1880
84-85	370	3000

---

* - Director published for educational software buyers in the school market by Sterling Swift Publishing (Austin, Texas)

EDUCATIONAL SOFTWARE		
PERSONAL COMPUTERS	NUMBER OF EDUCATIONAL SOFTWARE PUBLISHERS	NUMBER OF PROGRAMS
APPLE II	120-130	800-900
ATARI 400/800	30-40	250-300
COMMODORE PET/CBM	60-75	900-1000
COMMODORE VIC-20	15-20	400-500
IBM PERSONAL COMPUTER	30-35	40-50
TI-99/4A	20-25	400-500
TRS-80/I, III	150-180	900-1000
TRS-80 COLOR COMPUTER	10-15	70-100

© November,1982 Future Computing, Inc., 900 Canyon Creek Center, Richardson, Texas 75080

MAJOR CURRENT/POTENTIAL EDUCATIONAL SOFTWARE PUBLISHERS

Hardware Manufacturers

IBM
Apple
Atari
Commodore
Tandy
Texas Instru.
Timex

Entertainment/Game Producers

Avalon Hill
Broderbund
Creative Software
Data Most
Datasoft
Electronic Arts
Epyx
Infocom
Muse
Parker Brothers
Milton Bradley
Sierra On-Line

Synapse
Screenplay

Educational Software Companies

American Educational
Designware
Eduware
DLM
Milliken/Edufun
Educational Activities
Microcomputer Educational
Program Design

Entertainment/Education Companies

HES
Home Computer Software
Learning Company
Microlab
Scarborough
Spinnaker
Timeworks
Mecc
Computer Advanced Ideas
Counterpoint Software

Book Publisher

Hayden
McGraw-Hill
Readers Digest
Prentice Hall
Scott,Foresman
Scholastic
Xerox
Dilithium Pres
Simon & Schust
Random House
Bantam Books
John Wiley & Sons
Addison-Wesley
Dutton
Harper & Row
Houghton Miffli
Van Nostrand
Harcourt,Brace
Rand McNally
SRA

Figure 48. Which Software Publishers Have Been Most Popular in the Elementary School Market This Past Year?

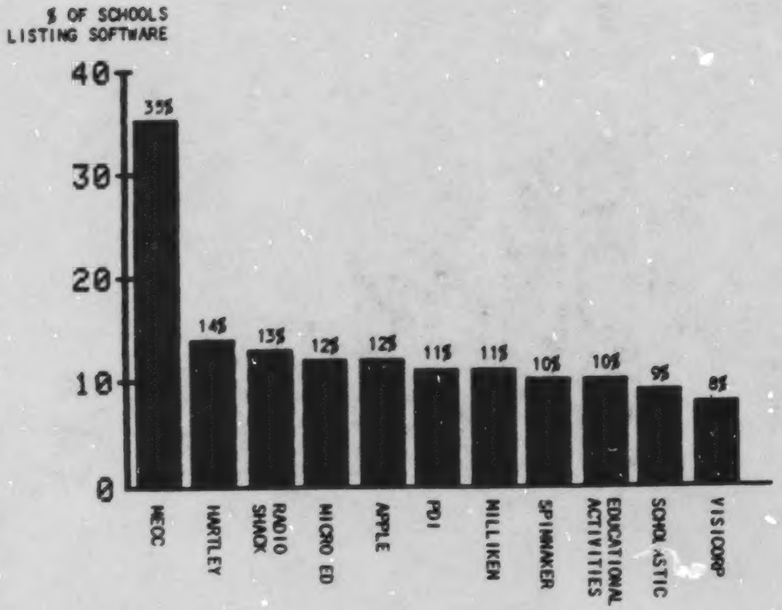
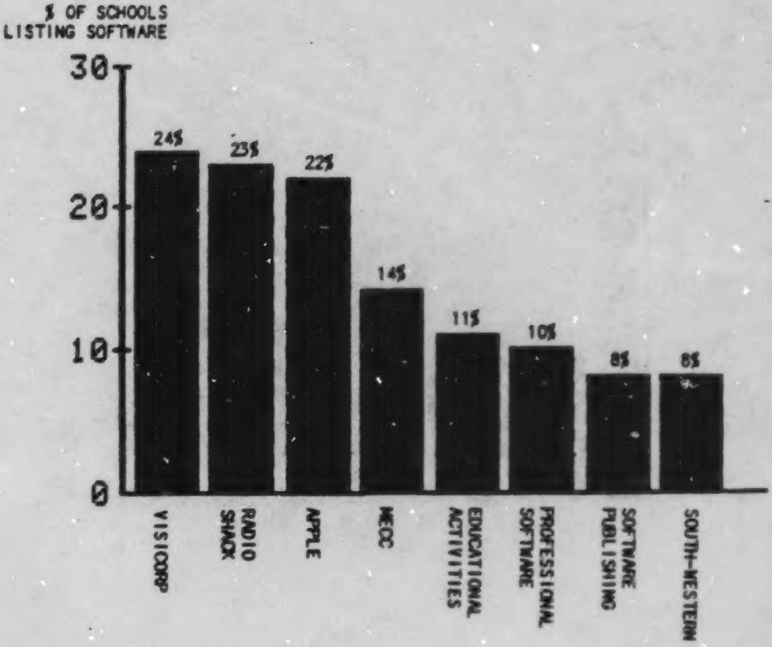


Figure 49. Which Software Publishers Have Been Most Popular in the Secondary Market This Past Year?



TALMIS

BEST COPY

APPENDIX VI

SUMMARY OF RECENT SCIENTIFIC RESEARCH ON THE EFFECTS OF COMPUTER-BASED EDUCATION ON ELEMENTARY SCHOOL PUPILS

Effects of Computer-based Education On Elementary School Pupils

Chen-Lin C. Kulik, James A. Kulik

& Robert L. Bangert-Drowns

The University of Michigan

A symposium paper presented at the annual meeting
Of the American Educational Research Association,
New Orleans, April 1984

Abstract

A meta-analysis of 29 comparative studies showed that computer-based education has generally had positive effects on the achievement of elementary school pupils. These effects have been different, however, for programs of off-line computer-managed instruction (CMI) and for interactive computer-assisted instruction (CAI). In 25 studies, CAI programs of drill and practice and tutorial instruction raised student achievement scores by 0.48 standard deviations, or from the 50th to the 68th percentile. In 4 studies, CMI programs raised student achievement scores by only 0.07 standard deviations. Study features were not significantly related to study outcomes.

Effects of Computer-Based Education
On Elementary School Pupils

Using computers to teach children is a topic of great interest currently to parents, teachers, and researchers, but it is also is a hard topic to bring into focus. Even the terminology in the area is open to dispute. The acronym CAI is often used, but it is variously interpreted as standing for "computer-assisted instruction," "computer-aided instruction," "computer-augmented instruction," and "computer-administered instruction." Other terms used in the area are "computer-managed instruction," "computer-based learning," and "computer-based instruction." "Computer-based education," or CBE, is becoming increasingly popular as a generic term for the area because it encompasses a broad spectrum of computer applications (Hall, 1982).

The first uses of the computer in teaching occurred in the late 1950s at IBM's Watson Research Center (Levien, 1972). By 1958 researchers there had already programmed a digital computer to teach binary arithmetic. In 1960 IBM researchers announced the development of the first CBE language, Coursewriter, designed to enable educators to develop instructional modules without the aid of computer specialists. By 1961 IBM's system of CBE was being used for teaching stenotype, German, and statistics.

Major developments in CBE occurred at university research centers in the years that followed (Hall, 1982). In 1959 engineers, physicists, psychologists, and educators at the University of Illinois, under the leaderships of Donald Bitzer, began developing the CBE system that was to become known as PLATO (Programmed Logic for Automatic Teaching Operators). In 1963 Patrick Suppes and Richard Atkinson began research and development on CBE at the Institute of Mathematical Studies in the Social Sciences at Stanford University. In 1964 Pennsylvania State University established a CAI laboratory under the leadership of Harold E. Mitzel for research, development, and implementation in CBE.

The taxonomies used to describe the approaches developed at such centers usually distinguished between four uses of the computer (Atkinson, 1968; Watson, 1972).

1. Drill and Practice. The teacher presents lessons to pupils by conventional means, and the computer provides practice exercises as a follow-up to teacher presentations.

2. Tutorial. The computer both presents the concepts and provides practice exercises on the concepts.

3. Dialogue. The computer presents both lessons and practice exercises, and the student is free to construct natural language responses, ask questions in unrestricted mode, and almost completely control the sequence of learning events.

4. Computer-managed Instruction. The computer evaluates students either on-line or off-line, guides students to appropriate instructional resources, and keeps records.

The development of the microchip during the late 1960s and the invention of simplified programming languages greatly increased learner access to computers and broadened researcher conceptions about he role that computers can play in education. In recent years both Luehrmann (1980) and Papert (1980) have suggested that early conceptions of a computer-teacher were too limited. They believe that learners who program the computer to solve problems develop a better understanding of the problems. They argue therefore that for the maximum educational benefit children should teach computers, not be taught by them. The computer's true role in education, they claim, is to be a servant of children who program it, not the master of children it programs.

Recent taxonomies of CBE reflect these new ideas about computer uses. Taylor (1980), for example, describes three uses of the computer in schools:

1. Tutor. When functioning as a tutor, the computer presents subject material, evaluates student responses, determines what to present next, and keeps records records of student progress. Most computer uses described in earlier taxonomies involve the tutoring function of computers.

2. Tool. The computer serves as a tool when students use it for statistical analysis, calculation, or word processing. For example, the computer can serve as a calculator in mathematics classes, as a map-maker in geography, as a performer in music, or as a text editor and copyist in English.

3. Tutee. Students can tutor the computer by giving it directions in a programming language the computer understands, e.g., BASIC or LOGO. Learners are thought to gain new insight into their own thinking through learning to program.

Systematic comparisons of outcomes of computer-based and conventional teaching began appearing in print in the late 1960s. In a typical evaluation study, a researcher divided a group of students into an experimental and a control group. Members of the experimental group received part of their instruction with computer assistance, whereas members of the control group received their instruction by conventional teaching methods. At the end of the experiment, the researcher compared responses of the two groups on a common achievement examination or on a course evaluation form.

Teachers and researchers carried out such studies in many settings during the past two decades. The studies varied in duration and in the number of students they involved. The studies were carried out with both commercial and locally designed materials. They were conducted as dissertation research, school-system evaluation projects, and university-sponsored studies. The evaluation designs of the studies included true randomized experiments and quasi-experiments.

Reviewers in recent years have tried to aggregate the results from the diverse evaluations in order to reach general conclusions about the effectiveness of CBE. Their reviews are of two basic types: box-score reviews and meta-analyses. Box-score reviews usually report the proportion of studies favorable and unfavorable to CBE, and often provide narrative comments about the studies as well. Reviewers using meta-analysis take a more quantitative approach to their task (Glass, McGaw, & Smith, 1981). They use (a) objective procedures to locate studies, (b) quantitative or quasi-quantitative techniques to describe study features and outcomes, and (c) statistical methods to summarize overall findings and explore relationships between study features and outcomes.

Reviewers using box-score methods concluded that CBE was effective in raising student achievement, especially in elementary schools. Vinsonhaler and Bass's review (1972), for example, reported that results from 10 independent studies showed substantial advantages for computer-augmented instruction. Elementary school children who received computer-supported drill and practice generally showed performance gains of 1 to 8 months over children who received only traditional instruction. According to Edwards, Norton, Taylor, Weiss, & Dusseldorp (1975) CBE often produced better results than did conventional teaching on end-of-course examinations. Findings were especially clear when CBE was used to supplement conventional teaching. Of the the nine relevant studies reviewed, all showed that normal instruction supplemented by CBE was more effective than was normal instruction alone. Edwards and his colleagues also noted that CBE reduced the time it took students to learn.

Hartley (1977), who was the first to apply meta-analysis to findings on CBE, focussed on mathematics teaching in elementary and secondary schools. She reported that the average effect of CBE was to raise mathematics achievement by 0.41 standard deviations, or from the 50th to the 66th percentile. Hartley also noted that although correlations between study features and outcomes were not generally high, a few study features significantly affected study outcomes. She pointed out, for example, that elementary students fared better with CBE than did secondary students. Burns and Bozeman (1981), like Hartley, used meta-analysis to integrate findings on computer-assisted mathematics instruction in elementary and secondary schools. They found overall effect sizes of 0.45 for computer-based tutorial instruction and 0.34 for drill and practice. They found virtually no evidence of a relationship between experimental design features and study outcomes.

Meta-analyses by J. Kulik and his colleagues covered a wider range of subject matters and computer applications than did the earlier syntheses. J. Kulik, Bangert, and Williams (1983) analyzed 51 studies of CBE conducted in Grades 6 through 12. They found that CBE raised the examination scores of students by 0.32 standard deviations, and also had positive effects on student attitudes and on the amount of time needed for instruction. In addition, J. Kulik, Kulik, and Cohen (1980) used meta-analysis to examine applications of CBE in college classes. The effect of CBE in a typical class was to raise student achievement by approximately 0.25 standard deviations, or from the 50th to 60th percentile. Kulik and his colleagues also reported that CBE substantially reduced the amount of time needed for instruction at the college level.

J. Kulik (1981) reviewed evidence from his own quantitative syntheses of findings and from Hartley (1977). Restricting his review to mathematics education, Kulik pointed out that CBE raised mathematics achievement scores by approximately 0.4 standard deviations at the elementary level, 0.3 standard deviations at the high school level, and 0.1 standard deviations at the college level. He concluded that CBE effectiveness may be a function of instructional level. He suggest that at the lower levels of instruction, learners need the stimulation and guidance provided by a highly reactive teaching medium. At the upper levels of instruction a highly reactive instructional medium may not be so necessary.

Further reviews are necessary to evaluate fully the model described by Kulik. Meta-analyses of elementary school applications of CBE have been especially limited in scope. They have been restricted to mathematics teaching and to drill-and-practice and tutorial applications of the computer. In addition, meta-analyses at this level are rapidly growing outdated. The meta-analyses by Hartley (1977) and by Burns and Bozeman (1981) covered no CBE studies published after 1978. Major changes have occurred in the use of computers in instruction during the years not covered in these meta-analyses.

The meta-analysis described in this article was designed to further explore the effectiveness of computer-based education in Grades 1 through 6. The article is meant to answer the sorts of questions commonly asked by research synthesists. How effective is computer-based teaching in general at the elementary school level? Is it especially effective for certain types of outcomes or certain types of students? Under which conditions does it appear to be most effective?

Method

The meta-analytic approach used in this review was similar to that described by Glass, McGaw, and Smith (1981). Their approach requires a reviewer (a) to locate studies of an issue through objective and replicable searches; (b) to code the studies for salient features; (c) to describe study outcomes on a common scale; and (d) to use statistical methods to relate study features to outcomes.

Data Sources

To find studies examining CBE effects on elementary school students, we carried out computer searches of two library data bases: (a) Comprehensive Dissertation Abstracts, and (b) ERIC, a data base on educational materials from the Educational Resources Information Center, consisting of the 2 files Research in Education and Current Index to Journals in Education. The empirical studies retrieved in these computer searches were the primary source of data for our analyses. A second source of data was a supplementary set of studies located by branching from bibliographies in the review articles retrieved in the computer searches.

These bibliographic searches yielded a total of 29 studies that met three criteria for adequacy. First, the studies had to take place in actual classrooms in Grades 1 through 6. Studies describing laboratory analogues of classroom teaching did not meet this guideline. Second, studies had to report measured outcomes in both CBE and control classes. Studies without control groups and studies with anecdotal reports of outcomes failed to meet this criterion. And third, the studies had to be free from such crippling methodological flaws as substantial aptitude differences in treatment and control groups, unfair "teaching" of the criterion test to one of the comparison groups, and differential rates of subject attrition from the groups being compared.

Study Features

A total of 21 variables were used to describe aspects of the experimental treatments used in the studies, study methodology, study settings, and publication history (Table 1). The variables were selected for this analysis on two grounds: (a) a review of variables used to describe study features in our previous meta-analyses, and (b) a preliminary examination of dimensions of variation in the studies located for this analysis. Three coders independently coded each of the studies on each of the variables. The coders jointly reviewed their coding forms and discussed any disagreements in their coding of the studies. These disagreements were resolved through further examination of the studies and discussion.

Insert Table 1 about here

Outcome Measures

The instructional outcome measured most often in the 29 studies was student learning, as indicated on achievement examinations given at the end of a program or on follow-up examinations given some time after the completion of the program. Other outcome measures included in the studies tapped noncognitive educational gains, including changes in student attitudes towards their school subjects and toward computers. Although analyses were done separately for each type of outcome, common procedures were used in coding the outcomes.

The goal in coding study outcomes was to overcome the difficulties caused by the variety of units in which studies reported a single type of outcome. Achievement effects, for example, were sometimes reported as gains in grade equivalent units, sometimes as raw-score changes, sometimes as percentile changes, and so on. Attitudinal effects were likewise reported in a number of different units. For statistical analysis of results, effects had to be transformed to a common scale.

The transformation used in this meta-analysis was the one recommended by Glass, McGaw, and Smith (1981). They coded each outcome as an Effect Size (ES), defined as the difference between the mean scores of two groups divided by the standard deviation of the control group. For studies that reported means and standard deviations for both experimental and control groups, ES was calculated directly from the measurements provided. For less fully reported studies, ES was calculated from statistics such as t and F.

The application of these formulas was straightforward in most cases. In some studies, however, several statistical measures were used to report results on a given outcome. For example, some investigators reported raw-score differences between groups as well as covariance-adjusted differences, and some reported differences on a post-measure as well as differences in pre-post gains. In such cases, we used as the numerator of *ES* the difference that gave the most accurate estimate of the true population effect. That meant using covariance-adjusted mean differences rather than raw-score differences, and differences in gains rather than differences on post-tests. In addition, some reports contained several measures of variation that might be considered for use as the denominator of *ES*. We used the measure that provided the best estimate of the population variation in the criterion variable.

Statistical Analysis

Researchers sometimes reported more than one finding for a given outcome area. Some of the multiple findings resulted from the use of more than one experimental or control group in a single study. Others resulted from the use of several subscales and subgroups in measuring a single outcome. Using several different *ES*s to represent results from one outcome area in one study seems inappropriate to us. The multiple *ES*s are not independent; they often come from a single group of subjects or overlapping subject groups, and in any case they represent the effects of a single program implemented in a single setting. To represent a single outcome by several *ES*s violates the assumption of independence necessary for many statistical tests and also gives undue weight to studies with multiple groups and multiple scales.

The procedure we adopted therefore was to calculate only one *ES* for each outcome area of each study. A single rule helped us to decide which *ES* best represented the study's findings. The rule was to use the *ES* size from the most methodologically sound comparison when comparisons differed in methodological adequacy:

1. When a study included both a conventionally taught control group and a no-treatment control group, results from the comparison with the conventionally taught group were coded for analysis. This procedure controlled for the possibly confounding effects of differential time-on-task.

2. When results from both a true experimental comparison and a quasi-experiment were available in the same study, results of the true experiment were coded.

3. When results from a long and short CBE implementation were available, results from the long implementation were used.

4. When transfer effects of CBE were measured in a study in addition to effects in the area of instruction, the direct effects were coded for the analysis.

In all other cases, our procedure was to use total score and total group results rather than subscore and subgroup results in calculating ES.

Statistical analyses were carried out separately for each outcome area. One study feature--control for historical effects--was dropped from the statistical analyses because of the lack of variation among studies in this feature. In all but one study, both the experimental and the control treatments were administered concurrently. Another study feature--type of computer interaction--was eliminated from the analyses because of its unacceptably high correlation with the variable indicating type of computer use. All studies of computer-managed instruction involved use of the computer for off-line processing; all but one of the studies of drill-and-practice and tutorial instruction involved mainframe computers with on-line interaction via terminals.

Results

Twenty-five of the 29 studies used in this analysis reported results from computer-assisted instruction (CAI) programs, involving drill-and-practice or tutorial instruction. Only 4 studies reported results from computer-managed instruction (CMI). The two sets of studies differed strikingly in their study features. In the 25 CAI studies, for example, students used the computer interactively; in the 4 CMI studies, the computer processed student records off-line. But more important, preliminary examination of results showed that the CMI and CAI studies produced strikingly different results (Table 2). For this reason, results from CMI and CAI studies were analyzed separately.

Insert Table 2 about here

Computer-Managed Instruction

The achievement of the control students exceeded slightly the achievement of students taught with computer-management in two studies (Akkerhuis, 1974; Coffman and Olsen, 1980), but the difference between groups in these studies was trivial and non-significant. The achievement of CMI students was trivially higher than that of control students in a study by Roberts (1982), but again the difference between groups was non-significant. In a study of CMI by Nabors (1974), however, the effect of CBE was positive and moderately high. The average ES in the four implementations, however, was 0.07. This average is clearly trivial in size.

The four studies provided little evidence for other positive effects of CMI. Only the study by Akkerhuis (1974) examined non-cognitive outcomes of instruction. In Akkerhuis's study the average ES on attitude toward subject was -0.20, and the average ES on attitude toward computers was -0.07. Both values are small or trivial in size, and neither can be considered statistically significant.

Computer-Assisted Instruction

The effects of CAI were clearly more positive than those of CMI. The clearest results were available on end-of-course achievement measures, but in other areas also results were basically positive.

Achievement Examinations. In each of 25 studies with results from achievement examinations, students from the CAI class received the better examination scores; in no study did students from the conventional class get better scores on a final examination on course content. A total of 20 of these 25 studies reported, in addition, that the difference between CAI and conventional classes was statistically significant. Overall, these box score results strongly favored CBE.

The index of effect size ES provides a more exact picture of the degree of benefit from CAI in the typical study. The average ES in the 25 studies was 0.48; the standard deviation of ES was 0.31; and its standard error was 0.063. The average ES for these CAI studies was significantly different from the average ES for CMI studies, $t(27) = 2.51$, $p < .02$.

The average ES of 0.48 for the CAI studies means that in the typical study, performance of CAI students was raised by 0.48 standard deviations. To interpret this effect more fully, it is useful to refer to areas of the standard normal curve. Approximately 68% of the area of this curve falls below a z-score of 0.48. We can conclude, therefore, that students from CAI classes performed at the 68th percentile on their examinations, whereas the students who received only conventional instruction performed at the 50th percentile on the same examinations. Or put in another way, 68% of the students from CAI classes outperformed the average student from the control classes.

Grade-equivalents provide another rough guideline for interpreting ESs. Glass et al. (1981) have discussed grade-equivalent units in the context of meta-analysis:

> By definition the average pupil will gain ten months of achievement in a school year, for example, the average third grade pupil will score 3.0 in early September and 4.0 by the end of the year. It is also known, as an empirical--not a definitional--fact that the standard deviation of most achievement tests in elementary school is 1.0 grade equivalent units; hence the effect size of one year's instruction at the elementary school level is about +1. (p. 103)

One can use this empirical relation between grade-equivalent scores and deviation-scores to estimate the approximate gain in grade equivalent units for CAI students. Their grade-equivalent scores would be nearly 5 months higher than the scores of comparable students taught by conventional teaching approaches.

Study features and achievement effects. Although the effect of CAI was moderate in the typical study, the size of effect varied from study to study. Effects of CAI ranged in size from a high of 1.3 standard deviations (Warner, 1979) to a low of 0.02 standard deviations (Easterling, 1982). It seemed possible that this variation in study outcome might be systematic, and we therefore carried further analyses to determine whether different types of studies were producing different results. These analyses, however, did not disclose any significant relationships between study features and final achievement scores (Tables 3 and 4).

Insert Tables 3 & 4 about here

Subgroup and subscore achievement effects. Several studies that were coded for overall achievement effects provided, in addition, information on scores of specific subgroups of students and on subtest scores as well as total test scores. Table 5 presents separate effect sizes for high and low ability students, primary and middle grade students, and scores on language and mathematics subtests in studies that reported more differentiated results.

Insert Table 5 about here

In each of the four studies that looked at effects separately for high and low aptitude students, the effects were greater on the low ability pupils. The average effect on the low ability students in the four studies was to increase achievement test scores by 0.55 standard deviations; the average effect on the high ability students was to increase scores by 0.06 standard deviations. Grade level, however, did not appear to be consistently related to effect size in the six studies that examined results in both primary and middle grades. In two of the studies, effects were higher in the middle grades, and in four studies effects were larger in the primary grades. Finally, the three studies that reported language and mathematic results separately did not produce evidence for differential effects. In one study mathematics effects were greater than language effects; in another study, the language effect was greater than the math effect; and in the third study the two effects were approximately equal in size.

Follow-up examinations. Four of the CAI studies reported results from follow-up achievement examinations administered after the completion of computer-based and conventional teaching. In each of the studies, the follow-up scores were higher in the CAI class than in the conventional class. Delon (1970) reported a follow-up ES of 0.30; Dunn, Morgan, and Richardson (1974) an ES 0.47; Litman (1977) an ES of 0.08; and Prince (1969) an ES of 0.38. The average ES in the four studies was 0.31; the standard deviation of ES was 0.17, and the standard error was 0.10.

Attitudes toward subject. Only one of the CAI studies presented student attitude results in a fashion that yielded an ES (Cranford, 1976). That study showed a small and statistically nonsignificant positive effect of CBE on student attitudes towards mathematics. The ES in the study was 0.10.

Discussion

The major finding in this study was the positive effect that CAI had on achievement of elementary school children. In the typical application, students received approximately 26 hours of CAI --15 minutes per day, for 4 days a week, and for a total of 26 weeks. The effect of this instruction was to raise student achievement scores by 0.48 standard deviations, or from the 50th to the 68th percentile. A gain of this magnitude is roughly equal to a gain in grade-equivalent scores of 5 months.

This average effect is similar to average results reported in earlier reviews. Vinsonhaler and Bass (1972) reported an average increase of 4.5 months on a grade-equivalent scale from computer-based drill and practice in elementary school mathematics and language arts. Burns and Bozeman (1981) and Hartley (1977) reported gains of approximately 0.4 standard deviations from CAI in elementary school mathematics. Our meta-analysis showed that CAI is still producing such positive results.

This meta-analysis provides additional support for J. Kulik's (1981) model describing effects of instructional technology on school learning. The model suggests that CAI will be most effective at the elementary level of teaching, less effective at the secondary level, and least effective at the higher educational level. The deduction is based both on the characteristics of learners at different stages of development and on the characteristics of the computer that are exploited in CAI. According to the model, learners in the lower grades profit most from a highly structured and reactive teaching medium; college students have less need for highly structured learning materials, immediate feedback, and teacher control.

Kulik's model predicts that CMI will be less effective with young learners than CAI will be. This is because CMI exploits different features of the computer. In CMI, the computer simply acts as the teacher's clerk. It scores tests, keeps records, and arranges schedules. It may carry out all these duties off-line, and students in a computer-managed class may never see the computer. CMI is a form of individualized instruction, and like other systems of individualized instruction, it requires learners to pace themselves properly, work independently, and make their own choices. These requirements may exceed the abilities and motivation of very young learners. It is not surprising therefore that the greatest successes of computer-managed and individualized instruction have come at the higher grade levels (J. Kulik, Kulik, & Cohen, 1979; J. Kulik, Kulik, & Cohen, 1981; Bangert, Kulik, & Kulik, 1983).

Like other meta-analyses carried out in recent years, this one did not find strong relations between study features and outcomes. Studies with different features produced similar outcomes. ESs were very similar, for example, in true experiments and quasi-experiments. In ten other meta-analyses that our research team has carried out on effects of instructional technology, results from true- and quasi-experiments have been nearly identical (Bangert-Drowns, Kulik, & Kulik, 1984), and so we were not surprised by our failure to find differences on this study feature. Results with other study features, however, were less predictable. Bangert, Kulik, and Williams (1983) have suggested, for example, that CBE programs are growing more effective with time. In the present meta-analysis, ESs from different time periods were very similar. Other researchers have speculated that time-on-task might explain some of the variation in outcomes of computer-based teaching (e.g., Suppes & Morningstar, 1969). In this meta-analysis, ESs were very similar for implementations with and without controls for time-on-task.

Although not statistically significant, some study features tended to be related to CAI effect size. First, the average ES in published studies tended to be larger than the average ES in dissertations. This trend was also apparent in our ten other meta-analyses on instructional technology (Bangert-Drowns, Kulik, & Kulik, 1984), and the difference between ESs in dissertations and those in published articles can now be considered one of the best established findings in the literature of meta-analysis. Second, ES also seemed to vary with study scale. ESs tended to be larger when computer-based teaching was restricted to a single subject matter and smaller with multiple-course implementation. ESs also tended to be larger with short rather than long implementations. A negative relationship between study scale and ES often appeared in our ten previous meta-analyses on instructional technology. More work will be needed, however, to explain the underlying factors that contribute to this relationship.

It is also important to note that the computer's overall record of effectiveness rests on specific computers used in specific ways for specific purposes. The record may not apply to machines, approaches, and objectives not examined in the studies in our meta-analysis. Current interest in instructional computing, for example, has been stimulated greatly by the development of microcomputers in the last 15 years. Microcomputer-based systems have their own characteristics: their own software, their own management systems, and their own scale of operations. Only 1 of the 29 studies located for this meta-analysis examined the effects of a microcomputer-based system. Evaluators will have to give much more attention in the future to effects of such microcomputer-based systems. This meta-analysis may be helpful in future evaluations in that it provides standards by which effects can be measured.

As dramatic as changes in hardware have been in recent years, they are no more important than the changes that have occurred in conceptions of computer-based teaching. Early applications of the computer in teaching capitalized on the computer's tutoring capabilities. Computers presented lessons, gave learners drill and practice on course material, and kept student records. Recent development have broadened teacher conceptions of the role that computers can play in education. In addition to serving a tutorial function, computers are now used by students as learning tools and even as "tutees." Our computer searches produced no adequate evaluation studies of these exciting new developments in computer-based elementary-school teaching. Evaluation work on these areas is badly needed.

Evaluators also need to investigate a wider range of educational outcomes than they have in the past. They have repeatedly examined computer effects on achievement scores, but they have given inadequate attention to pupil attitudes toward school, attitudes toward computers, and instructional efficiency. They have given almost no attention to higher order skills, transfer of gains to other areas, and interpersonal outcomes of computer uses in the classroom.

Educational evaluators are just now starting to turn their attention to such matters. It will take an enormous effort in the years ahead to produce a new set of up-to-date evaluation studies and to synthesize the findings from such studies. But judging by what has already been achieved, the effort may prove to be worthwhile. The years ahead promise to be exciting ones that may answer major questions about the best ways to use computers in teaching.

References

Akkerhuis, G. (1974). A comparison of pupil achievement and pupil attitudes with and without the assistance of batch computer-supported instruction. Dissertation Abstracts International, 4, 6345 A. (University Microfilms No. 74-09,052).

Atkinson, R. C. (1969). Computerized instruction and the learning process. In R. C. Atkinson & H. A. Wilson (Eds.), Computer-assisted Instruction: A book of readings (pp. 143-165). New York: Academic Press.

Bangert, R. L., Kulik, J. A., & Kulik, C.-L. C. (1983). Individualized systems of instruction in secondary schools. Review of Educational Research, 53, 143-158.

Bangert-Drowns, R. L., Kulik, J. A., & Kulik, C.-L. C. (1984). The influence of study features on outcomes of educational research. Paper presented at the annual meeting of the American Psychological Association, Toronto.

Burns, P. K., & Bozeman, W. C. (1981). Computer-assisted instruction and mathematics achievement: Is there a relationship? Educational Technology, 21, 32-39.

Chiang, A., Stauffer, C., & Cannara, A. (1978). Demonstration of the use of computer-assisted instruction with handicapped children, final report. (Report No. 446-AH-60076A). Arlington, VA: RMC Research Corporation. (ERIC Document Reproduction Service No. ED 166 913).

Coffman, W. E. and Olsen, S. A. (1980). The First Two Years of PLAN: An Evaluation of Program Impact. Iowa City, Iowa: Iowa Testing Programs. (ERIC Document Reproduction Service No. ED 190 674).

Cranford, H. R. (1976). A study of the effects of computer assisted instruction in mathematics on the achievement and attitude of pupils in grades five and six in a rural setting. Dissertation Abstracts International, 37, 5660A. (University Microfilms No. 77-5932).

Davies, T. P. (1972). An evaluation of computer assisted instruction using a drill and practice program. Dissertation Abstracts International, 32, 6970B. (University Microfilms No. 72-18,627).

Delon, F. G. (1970). A field test of computer assisted instruction in first grade mathematics. Educational Leadership, 28, 170-180.

Dunn, A. (1974). Computer-assisted instruction program. A three year report covering July 1, 1971 through June 30, 1974. Rockville, MD: Montgomery County Public Schools. (ERIC Document Reproduction Service No. ED 100 361).

Durward, M. (1973). Computer assisted instruction in arithmetic at South Hill Elementary School. British Columbia: Vancouver Board of School Trustees. (ERIC Document Reproduction Service No. ED 088 915).

Easterling, B. A. (1982). The effects of computer assisted instruction as a supplement to classroom instruction in reading comprehension and arithmetic. Dissertation Abstract International, 43, 2231 A. (University Microfilms No. 82-23,032).

Edwards, J., Norton, S., Taylor, S., Weiss, M., & Dusseldorp, R. (1975). How effective is CAI? A review of the research. Educational Leadership, 33, 147-153.

Fletcher, J. D. & Atkinson, R. C. (1972). Evaluation of the Stanford CAI program in initial reading. Journal of Educational Psychology. 63, 597-602.

Fejfar, F. L. (1969). ISU lab school fourth graders learn through CAI. Contemporary Education, 40, 296-297.

Glass, G. V., McGaw, B., & Smith, M. L. (1981). Meta-analysis in social research. Beverly Hills, Calif.: Sage Publications.

Grocke, M. (1982). Interactive Development of Reading Skills in an Educational Clinic. Australia, paper presented at the Annual National Conference of the Australian Group for the Scientific Study of Mental Deficiency. (ERIC Document Reproduction Service No. ED 223 993).

Haberman, E. L. (1977). Effectiveness of computer assisted instruction with socially/emotionally disturbed children. Dissertation Abstracts International, 38, 1998A. (University Microfilms No. 77-21,221).

Hall, K. A. (1982). Computer based education. In H. E. Mitzel (Ed.), Encyclopedia of educational research (pp. 353-363). New York: The Free Press.

Hartley, S. S. (1978). Meta-analysis of the effects of individually paced instruction in mathematics. Dissertation Abstracts International, 38(7-A), 4003. (University Microfilms No. 77-29,926)

Israel, B. L. (1968). Responsive environment program: Brooklyn, N.Y.: report of the first full year of operation. The talking typewriter. Brooklyn, NY: New York City Board of Education, Responsive Environment Program Center. (ERIC Document Reproduction Service No. ED 027 742).

Kulik, J. A. (1981). Integrating findings from different levels of instruction. Paper presented at the American Educational Research Association, Los Angeles. (ERIC Document Reproduction Service No. ED 208 040)

Kulik, J. A., Bangert, R. L., & Williams, G. W. (1983). Effects of computer-based teaching on secondary school students. Journal of Educational Psychology, 75, 19-26.

Kulik, J. A., Kulik, C.-L. C., & Cohen, P. A. (1979). A meta-analysis of outcome studies of Keller's Personalized System of Instruction. American Psychologist, 34, 307-318.

Kulik, J. A., Kulik, C.-L. C., & Cohen, P. A. (1980). Effectiveness of computer-based college teaching: A meta-analysis of findings. Review of Educational Research, 50, 525-544.

Levien, R. E. (1972). The emerging technology: Instructional uses of the computer in higher education. New York: McGraw-Hill.

Litman, G. (1977). Relation between computer-assisted instruction and reading achievement among fourth, fifth, and sixth grade students. Dissertation Abstracts International, 38, 2003A. (University Microfilms No. 77-20,883).

Luehrmann, A. (1980). Should the computer teach the student or vice-versa? In R. Taylor (Ed.), The computer in the school: Tutor, tool, tutee (pp. 129-135). New York: The Teachers College Press.

MacLean, R. F. (1974). A comparison of three methods of presenting instruction in introductory multiplication to elementary school children (total computer, partial computer, and non-computer. Dissertation Abstracts International, 35, 1430. (University Microfilms No. 74-19,759).

Mendelsohn, M. (1972). CAI in New York City: The slow learner in mathematics. National Council of Teachers of Mathematics Yearbook, 355-364.

BEST COPY

Morgan, C. E., Sangston, B. J., & Pokras, R. (1977). Evaluation of Computer-Assisted Instruction, 1975-76. Rockville, MD: Montgomery County Public Schools. (ERIC Document Reproduction Service No. ED 139 655).

Nabors, D. G. (1974). A comparative study of academic achievement and problem-solving abilities of black pupils at the intermediate level in computer-supported instruction and self-contained instructional programs. Dissertation Abstracts International, 36, 3241A. (University Microfilms No. 75-26,294).

Palmer, H. (1973). Three evaluation reports of computer-assisted instruction in drill and practice mathematics. CA: Los Angeles County Superintendent of Schools. (ERIC Document Reproduction Service No. ED 087 422).

Papert, S. (1980). Teaching children thinking. In R. Taylor (Ed.), The computer in the school: Tutor, tool, tutee (pp. 161-176). New York: The Teachers College Press.

Prince, J. D. (1969). A practitioner's report results of two years of computer assisted introduction in drill and practice mathematics. McComb, Mississippi, McComb Schools. (ERIC Document Reproduction Service No. ED 032 769)

Ragosta, M. (1983). Computer-assisted instruction and compensatory education: a longitudinal analysis. Machine-Mediated Learning, 1, 97-127.

Roberts, A. S. (1982). The effects of split-day scheduling and computer-managed instruction on the reading achievement of intermediate students. Dissertation Abstracts International, 43, 1482A. (University Microfilms No. 82-23,584)

Suppes, P. & Morningstar, M. (1969). Computer-assisted instruction. Science, 166, 343-350.

Taylor, R. P. (Ed.) (1980). The computer in the school: Tutor, tool, tutee. New York: The Teachers College Press.

Thompson, B. B. (1973). Effect of computer-assisted instruction on the language arts achievement of elementary school children. Dissertation Abstracts International, 33, 4077-4078A. (University Microfilms No. 73-3574)

Vinsonhaler, J. F., & Bass, R. K. (1972). A summary of ten major studies on CAI drill and practice. Educational Technology, 12, 29-32.

Warner, T. (1979). The Jackson elementary school computer based education mathematics project. Akron, OH: The University of Akron, Computer Based Education Center.

Watson, P. G. (1972). Using the computer in education. Englewood, NJ: Educational Technology Publications.

Wilson, H. A. & Fitzgibbon, N. H. (1970). Practice and perfection: A preliminary analysis of achievement data from the CAI elementary English program. Elementary English, 47, 576-579.

Author Note

The material in this report is based upon work supported by a grant from the Exxon Education Foundation. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the Exxon Education Foundation. The authors thank David Shwalb and Jolie Spring for their invaluable assistance in locating studies for the report.

Requests for reprints should be sent to Chen-Lin C. Kulik, Center for Research on Learning and Teaching, University of Michigan, 109 E. Madison St., Ann Arbor, Michigan 48109.

Table 1

Categories Used to Describe Study Features

Use of computer

Drill and practice -- The computer provided practice exercises but not the original lesson on a topic.

Tutorial -- The computer presented the lesson as well as practice exercises on the material.

Management -- The computer evaluated student performance, guided students to appropriate instructional resources, and kept records of student progress.

Author of program

Local -- Computer materials were developed locally for a specific setting.

Other -- Computer materials were developed for use in a wide variety of settings.

CCC materials

Yes -- Materials used in the study were developed at Stanford University and were obtained from the Computer Curriculum Corporation of Palo Alto.

No -- Other materials.

Type of computer interaction

Off-line

Terminal with mainframe

Microcomputer

Number of CBE sessions per week

Total number of weeks of CBE

Number of minutes per CBE session

Total amount of time on CBE (in minutes)

Subject assignment

Random -- Subjects were randomly assigned to the experimental and control groups.

Nonrandom -- A quasi-experimental design was used.

Control for instructor effects

Same instructor -- The same teachers or teachers taught both the experimental and control groups.

Different instructors -- Different teachers taught the two groups.

Control for historical effect

Same semester -- Subjects in experimental and control groups were taught concurrently.

Different semester -- Two groups were not taught concurrently.

Control for time-on-task

Experimental > Control -- Experimental subjects received regular instruction plus supplemental computer assistance.

Experimental = Control -- Total amount of instructional time was equal for experimental and control groups.

Control for test-author bias

Commercial -- A standardized test was used as the criterion measure for student achievement.

Local -- A locally developed test was used as the criterion measure.

Control for bias in test scoring

Objective -- Objective, machine-scorable examinations were used to measure student achievement, e.g., multiple-choice tests.

Nonobjective -- Subjective decisions had to be made in scoring tests, e.g., essay tests.

Field-tested computer materials

Yes

No

Control for evaluator involvement

Involved -- The evaluator was involved in developing the CBE material and/or in conducting the CBE program.

Not involved

Class level

Primary -- Subjects included in the study came from Grades 1 through 3.

Primary and middle -- Subjects came from both primary and middle grades.

Middle -- Subjects came from Grades 4 through 6.

Course content

Mathematics

Science

Language Arts and/or Reading

Combined -- More than one of the above were studied.

Subject ability level

Low

Average or mixed

High

Source of study

Unpublished -- ERIC document, paper presented at a convention, etc.

Dissertation

Published -- Journal article, book, etc.

Year of the report

Table 2

Major Features and Achievement Effect Sizes in 28 Studies of Computer-Based Education

Study	Place & Time	Grade	Course Content	Use	Weeks of Instruction	Achievement ES
Akkerhuis (1974)	Germany, 1972-73	6	M	Management	18	-0.06
Atkinson (1967)	California, 1966-67	1	L	Tutorial	25	0.47[a]
Chiang, Stauffer & Cannara (1978)	California, 1977-78		C	D & P	35	0.19
Coffman & Olsen (1980)	Louisiana, 1976-78	3,4	C	Management	72	-0.01
Cranford (1976)	Mississippi, 1975-76	5,6	M	D & P	12	0.64
Davies (1972)	California, 1971	3-6	M	D & P	16	0.34
Delon (1970)	Mississippi, 1968-69	1	M	D & P	36	1.08
Dunn, Morgan & Richardson (1974)						
Study I	Maryland, 1972-73	4	M	D & P	11	0.45
Study II	Maryland, 1972-73	6	M	D & P	30	0.44
Durward (1973)	Canada, 1973	6,7	M	D & P	6	0.19
Easterling (1982)	Texas, 1982	5	C	D & P	16	0.02
Fejfar (1969)	Indiana, 1967-68	4	M	D & P	4	0.80
Fletcher & Atkinson (1972)	California, 1969-70	1	L	D & P	22	0.81
Grocke (1982)	Australia, 1981	1-6	L	D & P	4	0.82
Haberman (1977)	Pennsylvania, 1974	4-6	M	D & P	8	0.57
Israel (1968)	New York, 1967-68	1,3	L	Tutorial	36	0.16
Litman (1977)	Illinois, 1972-73	4-6	L	D & P	36	0.23
MacLean (1974)	Pennsylvania, 1970-71	3-5	M	Tutorial	3	0.62
Mendelsohn (1972)	New York, 1968-69	2-6	M	D & P	20	0.49
Morgan, Sangston & Pokras (1977)	Maryland, 1975-76	3-6	M	D & P	60	0.23

BEST COPY AVAILABLE

Table 2 (continued)

Study	Place & Time	Grade	Course Content	Use	Weeks of Instruction	Achievement ES
Nabors (1974)	Missouri, 1973	5,6	S	Management	[illegible]	0.36
Palmer (1973)	California, 1972-73	4-6	M	D & P	16	0.36
Prince (1969)	Mississippi, 1967-68	1-6	M	D & P	36	0.64
Ragosta (1983)	California, 1977-81	1-6	C	D & P	108	0.30
Roberts (1982)	Utah, 1977-81	3-6	L	Management	108	0.02
Suppes & Morningstar (1969)	California, 1966-68	1-6	M	D & P	22	0.28
Thompson (1972)	Texas, 1970-71	4-6	L	D & P	36	0.11
Warner (1979)	Ohio, 1978-79	6	M	Tutorial	36	1.31
Wilson & Fitzgibbon (1970)	Michigan, 1969-70	4,5	L	D & P	16	0.40

Note. M = mathematics; L = language arts; S = science; D & P = drill and practice.

[a] This study yielded a statistically significant effect, but the report did not include enough detail for direct calculation of *ES*. The *ES* reported here and used in the analysis is an estimated value; it is the median *ES* in all studies of CBE that reported a statistically significant effect.

Table 3

Means and Standard Errors of Effect Sizes

For 25 CAI Studies Classified by Study Features

Categories	N	Effect Size	
		M	SE
Use of computer			
Drill and Practice	21	0.45	0.12
Tutorial	4	0.64	0.40
Author of program			
Local	10	0.45	0.17
Other	15	0.50	0.16
CCC material			
Yes	12	0.48	0.16
No	13	0.48	0.17
Duration of instruction			
One semester or less	11	0.47	0.16
One semester-one year	12	0.52	0.19
More than one year	2	0.26	0.21
Subject assignment			
Random	5	0.57	0.35
Nonrandom	20	0.46	0.12
Instructors			
Same	7	0.44	0.20
Different	18	0.49	0.14
Time-on-task			
Experimental > Control	15	0.44	0.15
Experimental = Control	10	0.53	0.19
Test author bias			
Commercial test	19	0.47	0.13
Local test	6	0.52	0.23
Evaluator involvement			
Involved	19	0.52	0.12
Not involved	6	0.36	0.28
Field-tested material			
Yes	17	0.49	0.15
No	8	0.45	0.20

Table 3 (continued)

Categories	N	Effect Size	
		M	SE
Class level			
Primary (1-3)	4	0.63	0.36
Primary & Middle (1-6)	9	0.43	0.17
Middle (4-6)	12	0.46	0.18
Course content			
Mathematics	15	0.56	0.15
Language/Reading	7	0.43	0.22
Combined	3	0.17	0.26
Ability of subjects			
Low	13	0.44	0.16
Average/Mixed	12	0.51	0.18
Nature of publication			
Unpublished	9	0.48	0.22
Dissertation	7	0.34	0.20
Published	9	0.59	0.18
Year of publication			
Before 1969	5	0.47	0.25
1970-1974	11	0.48	0.16
1975-1979	6	0.53	0.29
1980-1984	3	0.38	0.45

Table 4

Relationships of Time-on-Task Variables

to Achievement Effects in 25 CAI Studies

Variable	M	SD	r with ES
Sessions per week	4.08	1.63	0.10
Number of weeks	26.00	22.07	-0.17
Minutes per session	15.56	8.66	0.06
Total time-on-task in minutes	1564.50	2177.40	-0.10

Table 5

Effects Sizes for Subgroups and Subtests within Studies

Study	Ability		Content		Grades	
	Low	High	Language	Mathematics	Primary	Middle
Chiang, Stauffer, & Cannara (1978)			0.24	0.14		
Davies (1972)					0.18	0.39
Dunn, Morgan, & Richardson--Study I	0.55	0.35				
Durward (1973)	0.54	0.08				
Easterling (1982)			0.01	0.02		
Mendelsohn (1972)					0.62	0.40
Morgan, Sangston, & Pokras (1977)	0.23	0.13			0.17	0.24
Prince (1969)	0.89	-0.32			0.87	0.44
Ragosta (1983)			0.10	0.49	0.35	0.25
Suppes & Morningstar (1969)					0.40	0.16

COPY

Mr. **Walgren**. Thank you very much for that testimony.

Do you all agree that there seems to be a sorting out and a lack of a real problem of incompatibility? Mr. McQuillen indicates there are now sort of three dominant systems that are being used in schools. That would suggest a greater degree of uniformity than others. Is there any disagreement with the idea that incompatibility is not a major problem in the development of this area?

Mrs. **Rice**. Mr. Walgren, if I might begin commenting on that. I think there is no question that in the school marketplace, you are absolutely right, those are currently the three major players. But that is shifting, too. One can never really quite tell who else is going to be moving into those markets and it varies from place to place. For example, we are the strong—PLATO and Control Data are very strong in the Richmond and Toledo school systems and the District of Columbia school system. Our courseware is being adapted to a lot of the other vendors as well, but I think there still is a sorting out period through which we are all going and there is indeed at the moment little compatibility of the courseware.

Mr. **Walgren**. Little compatibility?

Mrs. **Rice**. Yes.

Mr. **Walgren**. Very little of that?

Mrs. **Rice**. Yes.

Mr. **Walgren**. Let me ask, not knowing very much about it, when you say you try to make your programs able to be used on other systems, could we expect that among these three anyway there will be translation readily available that would enable a program in one system to be able to be marketed for the others?

Mr. **McQuillen**. First of all, I just want to make a comment on Mrs. Rice's statement. We are talking about an issue of relativity. Three years ago, as a publisher, we were faced with an option of six, seven, eight machines. Three relative to that is a manageable number and even if the three players in the market were to shift, the economics of our business would allow us to produce a software progam very easily for three major machines in the marketplace. The economics would allow for that.

Mr. **Walgren**. The economics presently would allow you to——

Mr. **McQuillen**. Today a quality program in 3 or 4 months.

Ms. **Talley**. Compatibility is a difficult issue to address because it assumes that we know exactly what it is that we should have in those machines and exactly what is accomplishable and I think that as we look at different generations of computers, Apple has tried very hard to make within its own computer lines compatibility within the Apple II family. In order to do that, there are some sacrifices you have to make along the way. We make very difficult decisions always in bringing out new machines about which new features to add on which are technically possible to do at a very low cost and which ones we have to drop off because it would mean we are no longer compatible with the bases installed in the schools.

MacIntosh uses a much different method of having people interact with the computer, but it appears to have been very successful in terms of how students and teachers and the consumer interact with that machine. It points out some new ways of using computers that before perhaps weren't economically viable because of changes in technology. I guess the point is that until we reach a stage where we know a lot about what it is exactly we would like the hardware to be doing, to establish a hardware standard would prevent us from being able to add some new things to the machines that would make it easier for teachers and students to interact with those machines.

We may not be at the stage where we have all those answers, and as the market has grown enough, I would suggest that there is enough of a market within the schools that those people who have a large installed base will continue to be able to attract publishers for developing materials and those publishers will develop materials for anyone who has a large installed base.

Mr. **Walgren**. Let me ask you, you mentioned earlier that the Apple program in California cost the State of California $4 million and Apple $1 million. How did that—how do those numbers come about?

Ms. **Talley**. The fair market value for each of the computers that we donated was $2,000 a machine. The bill allows for 25-percent tax credit, 25 percent of the fair market value in terms of tax savings and then in addition, I think it should be pointed out that Apple, in the State of California, went well beyond the requirements of the legislation. We included software for which we were not given tax credits. We worked with publishers to give discounts on other kinds of software besides software that Apple produced.

We included manuals and background information for teachers to address additional training matters to make sure that the computers were indeed used in the classrooms. I think it is fairly clear that we did not abuse the use of that tax credit.

Mr. **Walgren**. It is an area where your costs are relatively low. Your costs must be then one quarter of the fair market value?

Ms. **Talley**. It is difficult to say that without being able to add in a lot of other costs that go along with doing business exactly what would be involved. It is another way of being able to get at the difficulty of schools acquiring computers and it is one way that ends up costing less perhaps in terms of tax dollars, relatively speaking, but allows everyone to acquire machines.

Dr. **Horwitz**. I would like to make a comment that relates to that question. The question gets at the question of Federal involvement and cooperation with the private sector with the Federal or State, public involvement in cooperation with private enterprise. The Quill project may be an interesting one to bear in mind. That was developed at public expense by Bolt, Beranek, Newman and another company called the Network, involved with teacher training and other issues, Department of Education funds.

It is now being marketed by D.C. Heath and the royalty stream from that is shared between the various participants in a way which is mutually satisfactory to us and is also making the software available to a rather large number and a growing number of educators and students. We did not have the resources to do the distribution, marketing, and sales of that software. That is not our business.

Clearly, the Government has neither the resources nor the mandate to do that. But with the Government's cooperation and funding of us today, the necessary research and early prototyping, there was then enough of an incentive in the private sector to do what was required to turn that into a product, which is not a trivial matter at all, and to do all of that marketing distribution and sales and the result has been something in which everyone has won, I believe.

Mr. **Walgren**. The thought was mentioned that the pre-NSF-NIE effort is very thin in teacher training, and that perhaps some of these dollars could usefully be put through present systems and have good effect.

Can you estimate, from your positions in the private sector, what is the size of our constructive effort on the Federal level that you would recognize? We had the Department of Education in, and they said, well, one of the things that they feel that indicates proper activity on the Federal level is that they are doing a study or they are going to do a study.

When I ask people about NSF trainerships, my local people tell me they thought they went out of business 10 years ago.

Can you estimate, if we were to use the route of the present established entities, can you make a judgment of what is the level of our present effort that you would expect on a nationwide basis, and how can that be measured against what we ought to be doing through presently established systems?

Ms. **Talley**. I will begin by commenting that probably the biggest single request that we get when giving followup support in installing our computers and equipment into the schools, is for additional teacher training.

It is also the most difficult for a hardware manufacturer to deal with because it begins to get into curriculum areas and specific subject areas that are not necessarily the day-to-day concern of someone dealing with making computers.

So, at least from my perspective, there must be a very high demand for teacher training and a continued need for that, because of the amount of demand that we get.

Mr. **Walgren**. Can you make an estimate of whether or not there is any there now? NSF was here this morning, alleging there was.

Mrs. **Rice**. To my knowledge for teacher training, it is extremely limited. I think that the math and science education program, which was a teacher training program, was cut or eliminated, I guess, early on. It may have had some small amount of moneys at NSF reinstated.

Maybe the NSF people here could say how much that currently is. To my knowledge, there is very, very little in the Department of Education.

Mr. **Walgren**. And the teacher training would be only what we are interested in if we are interested in our computer capabilities, that fraction of NSF teacher training that would be related to computer capabilities.

Is there a way of ball parking that?

Mrs. **Rice**. One example, as you know, there have been very aggressive and dynamic efforts here in the District of Columbia with our new school superintendent, Mrs. McKenzie, to foster partnerships with business.

She had a crying and desperate need to train her teachers and I know that for 3½ years now, there has been languishing in the Department of Education a modest proposal from the District of Columbia which everyone has found no fault with, but which has not been funded.

I think that has been replicated across the country. It doesn't seem to be an important thrust.

Dr. **Horwitz**. That is definitely true for Massachusetts.

Mr. **McQuillen**. From a publisher's point of view, it seems to be almost nonexistent. We have had a few situations with Federal moneys similar to what Dr. Horwitz described, the outcome has been very good for everyone involved.

What shocks me in coming to Washington today is the $15 million number for the task at hand and the goal that has been articulated here. We are not even in the ball park in terms of the kinds of funds that would be needed.

Ms. **Talley**. Going back to the work that I did before joining Apple, probably the most aggressive teacher training programs are done at State levels. If you look at the tech center program in California, the formation of MECK and other consortia in Minnesota for providing teacher training, and the use of technology in the schools, similar groups to that seem to be doing the majority of the effort around the country, the Florida Department of Education, other groups, that have become very involved at the State level or local level or consortia of school districts forming to go to provide the training.

That says to me that they are obviously doing that, because there is a need that is not being met by any other agency.

Mr. **Walgren**. Well, there is a great frustration on some of our parts, even given the validity of the reservations that you folks and others have expressed about these particular bills, the alternative is to apparently accept the presentation of evidence that, gee, we are doing some good things and we are doing everything that is proper to be done at this point, and yet, when we try to assess what it is that we are doing, to quote you, it is virtually nonexistent, and yet, obviously, we have problems in this area that would require a very existent effort on a nationwide basis.

Mr. **McQuillen**. I think you are getting some pretty consistent feedback that the national Government is needed and moneys are needed in large doses.

It is only the vehicles that are at issue here, at least from our perspective as publishers.

Dr. **Horwitz**. One final comment to place this in perspective, we are dealing with a situation in which, for some period of time, until quite recently, the Federal Government had made an implicit, at least, policy of getting out of this business.

The National Science Foundation education budget was zero a few years ago, and all of a sudden, about a year ago, we discovered this issue, and as I was at pains to point out, we have neither the technical expertise nor the financial resources behind anything like the kind of effort that I think in this room we tend to agree needs to be done, but it shouldn't be surprising that there is very little going on out there.

Until recently, the stated policy was to have a hands-off thing and kind of let it do its own thing.

Mr. **Walgren**. Mr. Brown, and if I could turn over the chair to you at this point.

Mr. **Brown**. I have no questions.

Mr. **Walgren**. On behalf of the committee, I want to thank you very much for your testimony. You have been very candid and direct, and concise, and it is very helpful in the communication process that we are trying to struggle through.

Mr. **Brown** [presiding]. The committee would like to ask the next panel to the table. Dr. Sherry Turkle, professor, program in science, technology and society, Massachusetts Institute of Technology, Cambridge, MA; Dr. Fredrick Bell, professor of mathematics and computer education, University of Pittsburgh, Pittsburgh, PA; and Dr. F. James Rutherford, chief education officer for the AAAS.

I would like to apologize for not having been here for the full course of the earlier panels, and my perspective may be a little distorted because of that, but what we are interested in doing is getting the benefit of your insight on this subject matter area, and the legislation before us, and knowing a little of your capabilities, I think that you will create a very good record, even without much help from the chairman.

Dr. Turkle, would you like to start with your testimony?

STATEMENT OF DR. SHERRY TURKLE, PROFESSOR, PROGRAM IN SCIENCE, TECHNOLOGY AND SOCIETY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA

Dr. **Turkle**. I am a sociologist and a psychologist. I work at MIT. I study the psychological and social effects of computers on people; for example, how the computer enters into children's development, enhancing some things, getting other kinds of things stuck, how it changes the nature of the classroom, how it changes relationships between parents and children, and between teachers and students.

In the list of questions that I was asked to address today, I was particularly struck by the wording of one, and it read, "What effect does the use of computers have in education on children? What effect does the use of computers in education have on children?"

I am sympathetic to the question, because I think it reveals our natural temptation, I think, a temptation born out of our anxiety, to look for a universal, isolable effect.

Technology X has effect Y, but in fact, my research in classrooms that have computers over the past 6 years suggests that the problem with such a question is precisely the search for a universal effect.

Different children—I think this is very fundamental—different children are touched in remarkably different ways by their experiences with computers, even the same computer. And so, my perspective is to turn the usual question around.

Instead of asking what the computer does to all children, I am going to be talking about what different kinds of children make of the computer, and I do this to support a particular point of view about what kinds of priorities there should be in software development.

This point of view is that the goal should be, must be, the creation of computational environments that allow this diversity to flourish, and I will try to say something about why this would do a great deal toward certain of the issues of equity that have been raised today, not only for the educationally and the culturally disadvantaged, but between women and men.

When different people, children as well as adults, sit down at computers, even when they sit down at the same computer to do the same job, their styles of interacting with the machine are very different.

In my own work, I have used the metaphor of computer as a Rorschach to sort of capture this phenomenon. My research has convinced me that these differences do not represent educational problems, but rather, unexploited in most cases, education opportunities to give the widest range of children, girls and boys, children with different personalities, with different social and cultural backgrounds, access to computer mastery.

And so, the goal of our research and development efforts must be to create environments where this diversity will be facilitated. It is not in general facilitated by most current software, and it will not be facilitated without a commitment, I believe a large Federal commitment, to fundamental research on the computer as a psychological machine, a machine that interacts in a complex way with people's individual psychology, development, a machine that different people need to interact with in different ways, and a machine where we need to understand the nature of that interaction better.

Let me begin by illustrating some differences in styles of computer interaction with a few vignettes that are taken from a study of an elementary school that I will call Austen.

This was a school whose computers used the LOGO computer language mentioned several times today. This is a software world that takes as its philosophy that the computer should be an expressive medium through which different children can express their natural tendencies to learn everything in different ways, a medium like a pencil or clay or paint.

At Austen, children turned the computer experience in very personal directions. In my written testimony, I speak of Jeff and Kevin, Jeff, who approaches the computer with determination and the need to be in control, who programmed his space shuttle program by making a plan.

Computer scientists will recognize this global top-down divide and concur strategy as good programming style, and I think we all recognize in Jeff someone who conforms to our stereotype of a computer person or an engineer, someone who organizes, who approaches the world of things with confidence and sure intent with the determination to make it work.

Kevin is a very different sort of child. Where Jeff is precise in all his actions, Kevin is dreamy and impressionistic, introspective. Kevin, too, at Austen made a space scene, but the way he went about it was not at all like Jeff's approach.

Jeff didn't care too much about the form of his rocket ship—was it attractive, what was important was getting a complex system to work together as a whole. But Kevin cared a lot about the esthetics. He spent a lot of time on the shape of the rocket, working really without plan, allowing himself to be led by the effects he produces, his mistakes led him to new ideas, from these come more experiments, trying out different colors, trying out different placements and trajectories of the rocket and its flares.

All of this leads him to more mistakes, more standing back, more admiring his evolving canvas. By the end of the week, Kevin, too, had programmed a space scene. Jeff and Kevin represent cultural extremes.

Scientific and technical fields are usually seen as the natural home for people like Jeff. The arts and humanities seem to belong to the Kevins. Why are their stories so important? Why do I want to tell you their stories today?

When you look at children in a classroom, it is quite sad, because you usually see the technical types, the Jeffs, doing technical things, and the arts and language people, the Kevins, doing nontechnical things or also commonly, we see each failing at the other's forte.

Watching Kevin and Jeff, and these are not isolated students at the same computer, shows us it is exciting because we see two different children, two very different children succeeding at the same thing; but although they are both succeeding at programming a computer, they are not doing it in the same way.

Each child developed a distinctive style of mastery: and I call them hard mastery and soft mastery. Hard mastery being the imposition of will really over the machine through the implementation of a plan, Jeff; soft mastery being more interactive.

Kevin reminded me of a painter who kind of stands back between brush strokes, looks at the canvas and only from that kind of interactive contemplation decides what to do next.

Hard mastery is the mastery of the engineer. Soft mastery, the mastery of the artist—try this, wait for a response, try something else, let the overall shape emerge from an interaction with the medium that really is more like a conversation than a monolog.

What is crucial here is that computers allow softs such as Kevin and in another language, these people have sometimes been thought of as the humanists, not the softs. It is a style of dealing with the material.

The computer allows softs such as Kevin, humanists, to operate in a domain of machines, mathematics, and formal systems that has long been thought to be a preserve of the "hards," of the scientists, of the engineers, of the children at school who are good with Tinker Toys and blocks and mathematics and things.

With a computer, a child like Kevin could march into a mathematical world with artistic colors flying full mast, opening up this kind of world to students to whom it has been closed.

I have used two boys as examples to talk about hard and soft masters without reference to gender, but now I would like to state what may seem obvious to you, that girls tend to be soft masters, and the hard masters are overwhelmingly male.

Girls try to forge relationships with the computer that relate to the computer's formal system because a computer is presenting the student with a formal system. Not as a set of unforgiving rules, but as a language for communicating with, negotiating with, a behaving, almost psychological entity.

As in the case of Kevin, there is conversation and give-and-take and in particular, for the girls, an involvement with computation as a sensuous, almost tactile medium.

The computer makes that possible. Now, I have talked about and tried to provide a small window on to some events in a fourth grade classroom, in order to make several points.

The first has to do with thinking about how to allow the widest diversity of children into the computer culture, and to use it as a path of access into, the broader scientific culture.

Children like Kevin tend to be afraid of technical objects and develop negative relationships with science and mathematics.

As they grow older, they often become increasingly defensive, but an early computer experience may make a difference. Unlike arithmetic, and school math drill, the computer offers a glimpse into the esthetic dimension of science and mathematics, and unlike arithmetic and school math, it provides a comprehensive medium to which soft masters are drawn.

In my experience, also drawn to it are students from culturally disadvantaged backgrounds, and this is something I would like to document in supplemental material with the committee's permission.

It gives them a point of entry into the computer culture, into a technical culture so that they will not be disenfranchised in a world in which political and social life is increasingly mediated by computation. This really is an end in itself.

They will not feel that all of that, all of that having to do with science and technology and computers and the future and rockets and space, and all of that, belongs to other kinds of people.

My second point is about women's access to the computer culture, again, in the larger sense to a scientific and technical culture. The concept of soft mastery, the mastery of the artist, the mastery of the humanist, the mastery of the Kevin may do more than give us a way to think about how computers in children's lives can serve as a bridge across a two culture divide.

It may also give us a way to think about the special problems of women and science, women and access to the technical culture. The computer which allows a soft point of entry into things scientific and technical may be our strongest instrument to date in breaking down the barriers between women and scientific careers.

I believe that educational software must be developed that opens out to diversity in children's styles of mastering it. This is a perspective that is not the norm in software development today.

The norm is for software that restricts style of use even though it often pays lip service to individualized learning. It is a path of least resistance. It is a path that industry follows, because, in fact, passive software that demands little is often favored by teachers who are still afraid of the new opportunities for diversity that the computer offers.

Thus, teacher training is crucial here, because to exploit the computer to its fullest potential you need to have a population of teachers who are not afraid of really what it can do.

Where public resources are needed is to develop software that goes in different directions, not in the direction of restraint, but rather in the direction of allowing the expression of the kinds of diversity that I have described a bit here.

Now, creating this software demands research, research, for example, on the relationship between personality, cognitive style and computational media. I think that this can only be done in research centers, not evaluation centers, that have as their mandate not software development in any simple sense, but really a comprehensive examination of the interaction, both social, psychological, as well as technical, between computers and people, as well as, I have pointed out, as a powerful effort in a very fundamental kind of teacher retraining, perhaps a better way to put it would be teacher consciousness raising.

In the meantime, I would like to just add a word about hardware, to say that there is nothing wrong with learning about the computer, in particular learning program skills; that is, using the computer as a tool to build something for yourself. It teaches a kind of thinking, it teaches a kind of reasoning—not all kinds, but it teaches some—and it gives access, and perhaps this to me is the most important thing, access to the manipulation of formal systems and thus it seems to me an entrance into a world of science and mathematics, a world, as I have pointed out, access to that world for people to whom these worlds have been closed before.

Bad software, bad educational software can be deadening and dull; superior in no way to traditional teaching methods. There is no premium on putting software into the classroom.

So I would like to just say a word for investment in hardware. It is not everything. But putting more computers in the hands of children does create a generation of child programmers who, at the very least, will not be afraid of the future.

Thank you.

[The prepared statement and biographical sketch of Dr. Turkle follow:]

Testimony before the Committee on Science and Technology

U.S. House of Representatives

Professor Sherry Turkle

Massachusetts Institute of Technology

What happens when young children, grade-school children, work with computers? Do computers change the way children think? Do they open children's minds or do they narrow their experience, for example making their thinking more linear and less intuitive? There is a temptation to look for a universal, isolable effect, the sort that still eludes experts on the effects of television.

My research suggests that the problem with such questions is the search for a universal effect. Different children are touched in remarkably different ways by their experience with computers. But by looking at how different children use the computer we can begin to think about the computer in education in a more meaningful way. And so my perspective today is to turn the usual question around: instead of asking what the computer does to all children, I ask what different kinds of children make of the computer.

I do this to support a particular point of view about priorities in software development: this is that the goal must be the creation of computational environments that allow this diversity to flourish.

In order to describe this diversity I have used the metaphor of "Computer as Rorschach." The Rorschach inkblot test provides ambiguous images, the inkblots, onto which the individual is asked to impose shape and form. The computer too, can take on many shapes and meanings. And as with the Rorschach, what people make of the computer depends on who they are as individual personalities.

When different people, children as well as adults, sit down at computers, even when they sit down at the same computer to do the "same" job, their styles of interacting with the machine are very different.

My research has convinced me that these differences do not represent educational "problems," but rather educational opportunities to give the widest range of children -- girls and boys, children with different personalities, with different social and cultural backgrounds -- access to computer mastery. And so, the goal of our research and development efforts must be to create environments where this diversity will be facilitated.

Let me begin by illustrating differences in styles of computer interaction with a few vignettes, taken from my study of an elementary school that I shall call Austen. The Austen school computers used the Logo computer language.② This language is embedded in a philosophy of education described by Seymour Papert, the mathematician and educator most associated with the development of Logo. Papert stresses noncompetitive learning and the use of the computer as a tool for intellectual development.

Two of Papert's images capture his ideas about computers and education. One is "the computer as pencil" -- that is, that computers should be as available and accessible to children as pencils and should be used for as broad a range of activities, "for scribbling as well as for writing, doodling as well as drawing, for illicit notes as well as for official classroom assignments."

Papert's second image is "the computer as mathland." The most natural way to learn to speak French is the way French children do, by speaking French to French-speaking people. By analogy, the most natural way to learn a mathematical language is through conversation with a mathematical-speaking entity and this is the computer. The child programs the computer. In "teaching" the machine, the child learns to speak its language, to become computer literate, to manipulate formal and mathematical systems. Papert calls this kind of natural learning "Piagetian" learning -- learning that hanpens spontaneously when people are in contact with the right materials. In this case the computer becomes a "right material," an expressive medium through which different children can express their natural tendencies to learn everything in different ways.

At Austen, children turned the computer experince in very personal directions.③ The stories of Jeff and Kevin illustrate contrasting approaches and suggest how the computer culture of tomorrow may have a broader base than the one of today.

Jeff, a fourth grader, has the widest reputation as a computer expert in the school. He is meticulous in his study habits, does superlative work in all subjects. His teachers were not surprised to se him excelling in programming. Jeff approaches the computer with determination and the need to be in control, the way he approaches both his schoolwork and his extracurricular activities. Jeff was the author of one of the first "Space-shuttle" programs to be done at Austen. He did it, as he does most other things, by making a plan. There would be a rocket, boosters, a trip through the stars, a landing. The program was conceived globally; then it was broken up into manageable pieces. "I wrote out the parts on a big piece of cardboard. I saw the whole thing in my mind just in one night, and I couldn't wait to come to school to make it work." Computer scientists will recognize this global "top-down," "divide and conquer" strategy as "good programming style." And we all recognize in Jeff someone who conforms to our stereotype of a "computer person" or an engineer -- someone who would be good with machines, good at science, someone organized, who approaches the world of things with confidence and sure intent, with the determination to make it work.

Kevin is a very different sort of child. Where Jeff is precise in all of his actions, Kevin is dreamy and impressionistic, introspective. ④ Where Jeff tries to impose his ideas on other children, Kevin's warmth, easygoing nature, and interest in others make him popular. Jeff has been playing with machines all his life, tinkertoys, motors, bikes, but Kevin has never really liked these toys. He likes stories, he likes to read, he is pround of "knowing the names of a lot of different trees." He is artistic and introspective.

Kevin too, has made a space scene. But the way he went about it was not at all like Jeff's approach. Jeff didn't care too much about the form of his rocket ship; what was important was getting a complex system to work together as a whole. But Kevin cares more about the aesthetics of the graphics. He spends a lot of time on the shape of his rocket. He abandons his original idea (claiming that "it didn't look right against the stars") but continues to "doodle" with the "scratchpad" shape maker his Logo computer provides. He works without plan, experimenting, throwing different shapes onto the screen. He frequently stands back to inspect his work, looking at it from different angles, finally settling on a red shape against a black night -- a streamlined, futuristic design.

Kevin is concerned primarily with creating exciting visual effects. He knows how to use the computer to write programs, but his programs emerge -- he is not concerned with imposing his will on the machine. He allows himself to be led by the effects he produces. Since he lets his plans change as new ideas turn up, his work has not been systematic. And so he often loses track of things. In correcting his errors, Kevin explores the system, discovering new special effects as he goes along. "Mistakes" lead him to new ideas -- from these come more experimentning, trying out of different colors, trying out of different placements for his rocket and its flares. He adds a moon, some planets. He tries out different trajectories for the rocket, different headings and different speeds for its travel. All of this leads to more mistakes, more standing back and admiring his evolving canvas. By the end of a week, Kevin, too, has programmed a space scene.

Jeff and Kevin represent cultural extremes. Some children are at home with the manipulation of formal objects, while others develop their ideas more impressionistically, usually with language or visual images, with attention to such hard-to-formalize aspects of the world as feeling, color, sound, and personal rapport. Scientific and technical fields are usually seen as the natural home for people like Jeff; the arts and humanities seen to belong to the Kevins.

When we look at children in a classroom, we usually see the "technical types" doing technical things and the "arts and language people" doing nontechnical things. Or we each failing at the others forte. Watching Kevin and Jeff at the same computer shows us two very different children succeeding at the same thing -- and here it must be said that Kevin not only succeded in creating a space scene, but, like Jeff, he learned a great deal about computer programming and mathematics, about manipulating angles, shapes, rates, and coordinates. But although succeeding at the same thing, programming a computer, they are not doing it the same way. Each child developed a distinctive style of mastery. These styles can be called "hard mastery" and "soft mastery."

Hard mastery is the imposition of will over the machine through the implementation of a plan. A program is the instrument of premeditated control. Getting the program to work is more like getting to "say one's piece" than allowing ideas to emerge in the give-and-take of conversation. The details of the specific program obviously need to be "debugged" -- there has to be room for change, for some degree of flexibility in order to get it right -- but the goal is always getting the program to realize the plan.

Soft mastery is more interactive. Kevin is like a painter who stands back between brushstrokes, looks at the canvas, and only from this contemplation decides what to do next. Hard mastery is the mastery of the planner, the engineer, soft mastery is the mastery of the artist: try this, wait for a response, try something else, let the overall shape emerge from an interaction with the medium. It is more like a conversation than a monologue.

In these stories, we see the computer acting as a Rorschach, allowing the expression of what is already there in the personalities and cognitive styles of these children. But the computer is more. It is a constructive as well as a projective medium. For example, it allows "softs" such as Kevin to operate in a domain of machines, mathematics, and formal systems that has long been thought to be a preserve of the "hards." With the computer, a child like Kevin could march into a mathematical world, a "mathland" in Papert's terms, with artistic colors flying full mast.

I have used boys as examples to talk about hard and soft masters without reference to gender. But now it is time to state what may seem obvious to many: girls tend to be soft masters and the hard masters are overwhelmingly male. Girls are trying to forge relationships with the computer that relate to the computer's formal system not as a set of unforgiving "rules," but as a language for communicating with, negotiating with, a behaving, psychological entity. As in the case of Kevin, there is "conversation," give-and-take, and in particular, an involvement with computation ac a sensuous, almost tactile medium.

I provided this window onto some events in a fourth-grade classroom in order to make two points. The first has to do with thinking about how to allow the widest diversity of children into the computer culture and to use it as a path of access into the broader scientific culture.

Children like Kevin tend to be afraid of technical objects and develop negative relationships with science and mathematics. As they grow older, they often become increasingly defensive. But an early computer exxperience might make a difference. Unlike arithmetic and school math drill,the computer offers a glimpse into the aesthetic dimension of science and mathematics. And, unlike arithmetic and school math, it provides an expressive medium to which soft masters are drawn. Whether or onto they go on to excel in computational, mathematical, or scientific studies is an open question. But they have a point of entry and they will not be disfranchised in a world in which political and social life is increasingly mediated by cmputation. They will not feel that "all of that" belongs to other kinds of people.

My second point is about women's access to the computer culture. The concept of "soft mastery" may do more than give us a way to think about how computers in children's lives can serve as a bridge across a "two-culture" divide. It may also give us a way to think about the special problems of women and science. The computer which allows a "soft" point of entry into things scientific and technical may be our strongest instrument to date in breaking down the barriers between women and scientific careers.

I believe that educational software must be developed that opens out to diversity in children's styles of mastering it. This is a perspective that is not the norm in software development today. The norm is for software that restricts style of use even though it often pays lip-service to individualized learning. Where public resources are needed is to develop software that goes in different directions, for example in the direction of allowing the expression of the kinds of diversity I have described here.

Creating this software demands research, research for example on the relationships between personality, cognitive style, and computational media. This can only be done in research centers that have as their mandate not software development in any simple sense, but comprehensive examination of the interactions, social and psychological as well as technical, between computers and people.

Curriculum Vitae
Sherry Turkle

Sherry Turkle
Associate Professor of Sociology
Massachusetts Institute of Technology
Room E51-201C
617-253-4068
Cambridge, MA 02139

221 Beacon Street
Boston, MA 02116
617-267-6467

Current Position

Associate Professor of Sociology, Massachusetts Institute of Technology, Program in Science, Technology, and Society.

Education

INSTITUTION	DEGREE	DATE
Harvard University (Sociology and Personality Psychology)	Ph.D.	1976
Harvard University (Sociology)	M.A.	1973
University of Chicago (Committee on Social Thought)		1970-71
Institut d'Etudes Politiques Paris, France	Certificat d'Etudes Politiques	1969
Harvard University, Radcliffe College (Social Studies)	A.B. summa cum laude	1970

Doctoral Thesis: "Psychoanalysis and Society: The Emergence of French Freud."

Fellowships and Honors

Guggenheim Fellowship, 1981-1982.

Rockefeller Humanities Fellowship, 1980-1981.

Mellon Fellow, Aspen Institute for Humanistic Studies, 1977.

Peter Livingston Award for Research in the Behavioral Sciences and Psychiatry, Harvard Medical School 1975-1976.

Dissertation Award from C. Douglas Dillon Chair of French Civilization, Harvard University, 1974.

Alliance Francaise de New York Fellowship, 1970.

Danforth Fellowship, 1970-1976.

Phi Beta Kappa, Radcliffe College, 1970.

Professional Experience

Academic Appointments:

1980 - Present	Associate Professor of Sociology, Massachusetts Institute of Technology.
1976 - 1980	Assistant Professor of Sociology, Massachusetts Institute of Technology.
1976 - Present	Member, Laboratory for Computer Science, Massachusetts Institute of Technology.
1975 - 1976	Research Fellow in Sociology, Massachusetts Institute of Technology.
1971 - 1973	Tutor and Teaching Fellow in General Education, Social Relations, and Social Studies, Harvard University.

Other MIT Activities:

1977 - 1979	Chair, Faculty Committee on the Student Environment.
1978 - 1979	Ad hoc Faculty Committee on Advising.
1978 - Present	Advisory Committee, Nightline (Peer Counseling Service).
1978 - 1979	Steering Committee, Seminar Program on Computers and Society, Program in Science, Technology, and Society.
1978 - Present	Committee Service, Program in Science, Technology, and Society (1978 - Present: Curriculum Committee; 1981 - Present: Exxon Fellowship Committee).
1976 - 1977	Co-director, Lilly Endowment Postdoctoral Teaching Award Fellowship Program, Division for Study and Research in Education.

Other Professional Experiences:

1981 - Present	Planning Committee, Computers and Society, New York Academy of Sciences.
1981 - Present	Panel on Computers and Privacy, American Bar Association.
1979 - Present	Advisory Panel for the Assessment of the Societal Impacts of National Information Systems, Office of Technology Assessment, Congress of the United States.
1978 - Present	Licensed Psychologist, Commonwealth of Massachusetts.
1974 - 1975	Intern in Psychology to the Harvard University Health Services, Holyoke Center, Cambridge, MA.
1971 - 1973	Clinical Intern, Outpatient Psychiatric Clinic of the Cambridge Hospital, Cambridge, MA.
1971 - 1972	Participant, Research Seminar for Social Scientists, Boston Psychoanalytic Institute, Boston, MA.

Areas of Current Research

The Social and Psychological Impact of the Computer Presence.

The Sociology of Sciences of Mind (emphasis on Psychoanalysis and Artificial Intelligence).

Professional Organizations

American Sociological Association

International Sociological Association

American Association for the Advancement of Science

American Psychological Association

Invited Lectures, Seminars, and Colloquia

Brandeis University; Harvard University; University of Pennsylvania; Institute for Advanced Study at Princeton University; Massachusetts Mental Health Center; Harvard Medical School; Worcester Polytechnic Institute; Massachusetts Institute of Technology (Technology Day); Institut de Recherche d'Informatique et d'Automatique, Paris; Swedish Council for Coordination and Planning of Research; Columbia University, Distinguished Lecturer in Computer Science; American Association of Teachers of French; The New York Freudian Society; The National Computer Science Association of Brazil; New York University.

Papers Given at Professional Meetings

"Science and the Larger Culture: The Role of the Object," Symposium of the Program in Science, Technology, and Society, Massachusetts Institute of Technology, December 1981, Cambridge, Massachusetts.

"The Subjective Computer," The Annual Meeting of the International Federation of Information Processors, September 1980, Tokyo, Japan.

"Personal Computers," The Annual Meeting of the American Association for the Advancement of Science, January 1980, San Francisco, California.

"The Subjective Side of Computation," The Annual Meetings of the American Sociological Association, August 1979, Boston, Massachusetts.

"Social Problems Implicit In Computer Technology," Annual Meetings of the American Sociological Association, September 1977, Chicago, Illinois.

"The Social Roots of Psychoanalytic Cultures," Annual Meetings of the American Sociological Association, September 1977, Chicago, Illinois. "Professionalization and the Normalization of Subversive Sciences," Annual Meetings of the Eastern Sociological Association, March 1977, New York, New York.

"The Changing Social Image of Psychoanalysis in France: Survey Results," Annual Metings of the International Society of the Sociology of Knowledge, September 1976, New York, New York.

"Levi-Strauss on Rousseau as Founder of the Science of Man," Annual meetings of the American Sociological Association, August 1976, New York, New York.

"French Sociology and the Events of May-June 1968: The Microcosm and Its Field," Annual Meetings of the American Anthropological Association, September 1972, New York, New York.

Publications

Books:

The [illegible]

~~*The Intimate Machine: Social and Cultural Studies of the Computer Presence*, forthcoming~~ [illegible] Simon [illegible] 1984.

Psychoanalytic Politics: Freud's French Revolution, New York, Basic Books (1978).

Published Articles:

"Lacan and America: The Problem of Discourse," in *Introducing Psychoanalytic Theory*, S. Gilman (ed.), New York, Bruner Mazel, in press.

"The Subjective Computer: A Social and Psychological Study of Personal Computation." *Social Studies of Science*, 12,2 (May 1982), 173-205.

Introduction to the French Edition of *Psychoanalytic Politics: Freud's French Revolution*, Paris, Grasset (1981).

"Mon Oncle de Marienbad: Sociobiology Comes to the Land of the Structuralists," *Contemporary French Civilization*, VI, 1-2 (Fall/Winter 1981-2), 67-77.

"The New Philosophy and the Agony of Structuralism: Enter the Trojan Horse," *Chicago Review*, 32, 3 (Winter 1981), 11-28.

"Is Paris Kidding? The Clown Coluche Runs for President," *The Soho News* (January 14, 1981).

Review Essay on *The Ecrits* and *The Four Fundamental Concepts of Psychoanalysis* by Jacques Lacan, *Theory and Society*, 9, 4 (July 1980), 655-661.

"French Antipsychiatry" in *Critical Psychiatry: The Politics of Mental Health*, D. Engleby (ed.), New York, Pantheon (1980),150-183.

"Computer as Rorschach: Subjectivity and Social Responsibility," *Society* (January-February 1980), 15-24.

"An Ambivalent Anniversary," *The Boston Pheonix*, with N. Rosenblum (June 1979).

"Sense over Sound," a review essay on Michel Foucault, *The Nation*, 288, 3 (1979), 92-94.

"French Psychoanalysis: A Sociological Perspective," in *Psychoanalysis, Creativity, and Literature: A French-American Inquiry*, A. Roland (ed.), New York, Columbia University Press (1978), 39-71.

"The Americanization of Sex and Consciousness," a review essay, *Working Papers for a New Society*, IV,3 (Fall 1976), 67-74.

"Symbol and Festival in the Events of May and June 1968," in *Symbol and Politics in Communal Ideology: Cases and Questions*, B. Meyerhoff and S. Moore (eds.), Ithaca, NY, Cornell University Press (1976), 68-100.

"Contemporary French Psychoanalysis: Analytic Societies and the Structure of the Movement," *The Human Context*, VII, 3 (Autumn 1975), 561-69.

"The History of the French Psychoanalytic Movement," *The Human Context*, VII, 2 (Summer 1975), 333-43.

"The Balint Group and the End of One-Person Medicine," *Psychologie*, 54 (July 1974), 47-55.

CHAPTER 3

Child Programmers: The First Generation

Consider Robin, a four-year-old with blond hair and a pinafore, standing in front of a computer console, typing at its keyboard. She is a student at a nursery school that is introducing computers to very young children. She is playing a game that allows her to build stick figures by commanding the computer to make components appear and move into a desired position. The machine responds to Robin's commands and tells her when it does not understand an instruction. Many people find this scene disturbing. First, Robin is "plugged into" a machine. We speak of television as a "plug-in drug," but perhaps the very passivity of what we do with television reassures us. We are concerned about children glued to screens, but, despite what we have heard of Marshall McLuhan and the idea that "the medium is the message," the passivity of television encourages many of us to situate our sense of its impact at the level of the content of television programming.[1] Is it violent or sexually suggestive? Is it educational? But Robin is not "watching" anything on the computer. She is manipulating—perhaps more problematic, *interacting with*—a complex technological medium. And the degree and intensity of her involvement suggests that (like the children at the video games) it is the medium itself and not the content of a particular program that produces the more powerful effect. But beyond any specific fear, so young a child at a computer conflicts with our ideal image of childhood. The "natural" child is out of doors; machines are indoors. The natural child runs free; machines control and constrain. Machines and children don't go together.[2]

Something else feels discordant, and that is the nature of Robin's interaction with the computer. She is not manipulating the machine by turning knobs or pressing buttons. She is writing messages to it by spelling out instructions letter by letter. Her painfully slow typing seems laborious to adults, but she carries on with an absorption that makes it clear that time has lost its meaning for her. Computers bring writing within the scope of what very young children can do. It is far easier to press keys on a keyboard than to control a pencil. Electronic keyboards can be made sensitive to the lightest touch; more important, they permit instant erasure. The computer is a forgiving writing instrument, much easier to use than even an electric typewriter.

That a four-year-old or a three-year-old might learn to make a fire poses a real physical danger, but it does not call anything about childhood into question. We find it easy to accept, indeed we are proud, when children develop physical skills or the ability to manipulate concrete materials earlier than we expect. But a basic change in the child's manipulation of symbolic materials threatens something deep. Central to our notion of childhood is the idea that children of Robin's age and younger speak but do not write.

Many people are excited by the possibility that writing may be brought within the range of capabilities of very young children. But others seem to feel that setting a four-year-old to writing does violence to a natural process of unfolding. For them, what is most disturbing about Robin is not her relationship to the machine, but her relationship to writing, to the abstract, to the symbolic. Opening the question of children and writing provokes a reaction whose force recalls that evoked by Freud's challenge to the sexual innocence of the child.

In the eighteenth century, Jean-Jacques Rousseau associated writing with moral danger in the most direct way.[3] He saw the passage from nature to culture as the end of a community of free, spontaneous communication. Writing marked the point of rupture. In Rousseau's mind, this story of loss of community and communication projects itself onto the life of each individual. Each growing up is a loss of innocence and immediacy, and the act of writing symbolizes that the loss has taken place. To a certain extent, each of us reenacts the fall. Our first marks of pen on paper retrace the introduction of a barrier between ourselves and other people. Childhood, innocence, is the state of not writing.

The computer has become the new cultural symbol of the things that Rousseau feared from the pen: loss of direct contact with other people, the construction of a private world, a flight from real things to their representations. With programming, as for so many other things, the computer presence takes what was already a concern and gives it new form and new degree. If our ideas about childhood are called into question by child writers, what of child programmers? If childhood innocence is eroded by writing, how much more so by programming?

What happens when young children, grade-school children, become programmers?[4] Faced with the reality of child experts who have appropriated the computers that dot grade schools and junior highs across the country, there is talk of a "computer generation" and of a new generation gap.

Sarah, a thirty-five-year-old lawyer and mother of three, feels an unbridgeable gap between herself and her son, and she alternates between agitation and resignation:

> I could have learned that "new math." I could understand, respect my son if his values turn out to be different than mine. I mean, I think I could handle the kinds of things that came up between parents and kids in the sixties. I would have talked to my son; I would have tried to understand. But my ten-year-old is into programming, into computers, and I feel that this makes his mind work in a whole different way.

Do computers change the way children think? Do they open children's minds or do they dangerously narrow their experience, making their thinking more linear and less intuitive? There is a temptation to look for a universal, isolable effect, the sort that still eludes experts on the effect of television.

The problem here is the search for a universal effect. I have found that different children are touched in remarkably different ways by their experience with the computer. However, by looking closely at how individual children appropriate the computer we can build ways to think about how the computer enters into devel-

BEST COPY

opment, and we begin to get some answers to our questions. In a sense, I turn the usual question around: instead of asking what the computer does to children I ask what children, and more important, what different kinds of children make of the computer.

A Setting for Diversity

I observed child programmers in a variety of school settings. In most schools there was one or perhaps two computers per grade. In a few, every classroom had at least one computer. And in one special situation, every child had unlimited computer access. The children I observed programmed in a number of languages, including BASIC, PILOT, and Logo.[5] In every setting it was apparent that computers had brought something new into the classroom. In every classroom there were some children who were particularly excited about programming, who shared ideas with other child programmers, who began to build an intellectual community. These children often found themselves in an unusual situation: in this domain they became experts, even more expert than their teachers. In many classrooms this spontaneous emergence of intellectual community was limited to a particular kind of child, typically boys with strong interests in math or electronics or other things technical. This does not mean that other children did not learn to program. In fact, in several of the classrooms they were required to do so. But they did so in the spirit of trying to do well in a school activity and of trying to conform to a set of expectations imposed from without. What was remarkable in the school where there was unlimited computer access was the range of children who became seriously involved with the computer. In this environment, where the computer experience was relatively free from curricular expectations, children developed highly individualized approaches to programming that provided a window onto larger issues of intellectual style and personality.[6]

A private school that I shall call Austen, with children from preschool through fourth grade, was the site of a broadly conceived research project involving the design of a special computer, the training of a group of teachers, and a research program to study the children's progress. All the children at Austen had access to computers, and a group of about fifty third and fourth graders were offered a more intensive experience. Fifteen of them, chosen for the diversity of their backgrounds, interests, and talents, were studied in depth. The school itself had a long tradition of open classrooms and flexible scheduling, which facilitated the integration of computers into classroom life. At almost any time of the day I saw children, working alone or in groups, at small personal computers scattered throughout the school.

At Austen, programming was not treated as a "school subject." The children had liberal access to the machines, to program as they wished. The general ferment of activity that resulted was so great that teachers could not closely monitor the children or impose an "official" way of doing things even if they had wanted to. And in this case, there was also an explicit commitment to encouraging the children to appropriate the project as their own.

This is not a school that "brought in some computers," but a school that created conditions for the growth of a computer culture. The intention was to simulate a future where computers would be everyday objects in the life of the child.

The Austen School used the Logo computer language. It is embedded in a philosophy of education described in *Mindstorms* by Seymour Papert, the mathematician and educator most associated with the development of Logo. Papert stresses noncompetitive learning and the use of the computer as a tool for intellectual development.

Two of Papert's images capture his ideas about computers and education. One is "the computer as pencil"—that is, that computers should be as available and accessible to children as pencils and should be used for as broad a range of activities, "for scribbling as well as for writing, doodling as well as drawing, for illicit notes as well as for official classroom assignments."[6]

Papert's second image is "the computer as mathland." The most natural way to learn to speak French is the way French children do, by speaking French to French-speaking people. By analogy, the most natural way to learn a mathematical language is through conversation with a mathematical speaking entity, and this is the computer. The child programs the computer. In "teaching" the machine, the child learns to speak its language and manipulate formal and mathematical systems. Papert calls this kind of natural learning "Piagetian" learning—learning that happens spontaneously when people are in contact with the right materials. One of the most striking things about the Austen project was the way in which the creation of a child programming culture created new relationships between students, teachers, and curriculum.[*]

Commonplace assumptions about what happens in schools did not hold true for the computer-rich Austen classrooms: that teachers know more than students, that teachers are more interested than students, and that it is the teacher's job to design artful ways to motivate children to learn things that would not come naturally to them.

Such assumptions are called into question when children are in passionate relationships with the learning material and when that material allows for its own natural exploration. An example may help to make the point. It is fairly clear that children playing video games show improved hand–eye coordination and learn how to decode the rules behind each game's structure. Imagine a situation in which teachers tried to "teach" children video games in order to work on these skills. The idea seems foolish because we know that children learn these games although they come with virtually no instructions. Children dive into their exploration. They watch others play, they figure it out for themselves. It is much like this with interactive computers. Children can learn a great deal without being taught. Many children move beyond their teachers in their degree of interest and even their expertise. In these cases teachers take on the role of guides to what is very much a new territory for them as well as for their students.[*]

A Children's Computer Culture

When children learn to program, one of their favorite areas of work is computer graphics—programming the machine to place displays on the screen. The Logo graphics system available at Austen was relatively powerful. It provided thirty-two computational objects called sprites that appear on the screen when commanded to do so. Each sprite has a number. When called by its number and given a color and shape, it comes onto the screen with that shape and color: a red truck, a blue ball, a green airplane. Children can manipulate one sprite at a time, several of them, or all of them at once, depending on the effect they want to achieve. The sprites can take predefined shapes, such as trucks and airplanes, or they can be given new shapes designed on a special grid, a sprite "scratchpad." They can be given a speed and a direction and be set in motion. The direction is usually specified in terms of a heading from 0 to 360, where 0, would point the sprite due north, 90 would point it due east, 180 south, 270 west, and 360 north again.

---

[*] I followed the Austen project from its inception, spoke to the teachers during their training, and then when the machines were in place observed and interviewed the students and had access to the results of the psychological tests—Rorschach, WISC (IQ), Locus of Control—that had been administered to the fifteen children selected for special study. The study of the Austen students was a collaborative effort with Seymour Papert and John Berlow.

[*] Of course, some students respond less enthusiastically, less successfully. This chapter describes children who did get involved, in order to discuss the relationships between programming and personality. The phenomena discussed in this chapter could happen because a sufficient number of children became deeply involved to constitute a "subculture" that developed a degree of autonomy and that attracted very different kinds of children.

At the time the system was introduced, the teachers thought the manipulation of headings would be too complex for second graders because it involves the concept of angles, so these children were introduced to the commands for making sprites appear, giving them shapes and colors, and placing them on the screen, but not for setting them in motion. Motion would be saved for later grades.

The curriculum held for two weeks. That is, it held until one second grader, Gary, caught on to the fact that something exciting was happening on the older children's screens, and knew enough to pick up the trick from a proud and talkative third grader. In one sense, the teachers were right: Gary didn't understand that what he was dealing with were "angles." He didn't have to. He wanted to make the computer do something, and he found a way to assimilate the concept of angle to something he already knew—secret codes. "The sprites have secret codes, like 10, 100, 55. And if you give them their codes they go in different directions. I've taught the code to fourteen second graders," he confided to a visitor. "We're sort of keeping it a secret. The teachers don't know. We haven't figured out all the codes yet, but we're working on it." Two weeks later, Gary and his friends were still cracking the code. "We're still not sure about the big numbers" (sprites interpret 361 as 1, one full revolution plus 1), but they were feeling very pleased with themselves.

Gary's discovery, not the only one of its kind, contributed to creating a general pattern at Austen. Students felt that computer knowledge belonged to them and not only to the teachers. Once knowledge had become forbidden fruit, once appropriation of it had become a personal challenge, teachers could no longer maintain their position as the rationers of "curricular materials." In a setting like Austen, ideas about programming travel the way ideas travel in active, dynamic cultures. They sweep through, carried by children who discover something, often by chance, through playful exploration of the machine.

Gary and his fellow decoders finally presented their discoveries to the authorities with pride of authorship. At Austen programming tricks and completed programs are valued—they are traded and they become gifts. In traditional school settings, finished book reports are presented to teachers who try to instill a sense of the class as community by asking the children to read them aloud to the group. In the context of children and programming projects, the sharing usually happens naturally. Children can't do much with each other's book reports, but they can do a great deal with each other's programs. Another child's program can be changed, new features can be added, it can be personalized. (One child can figure out how to get the computer to engage in a "dialogue," but a second child can change the script; one child can figure out how to write a program that will display an animated drawing of a rocket going to the moon, but a second child can build on it and have the rocket orbit once it gets there.) Most objects can't be given away and kept at the same time. But computer programs are easily shared, copied from one child's personal storage disk or cassette to that of another. As the child experiences it, the originator of the program gets to be famous. And other people get to build on his or her ideas.

Anne, an artistic fourth grader, had originated a program in which birds made of sprites fly across the sky and disappear behind clouds. One morning as we spoke, she glanced around the classroom. Five of the eight computers within view had objects disappearing, melting, and fading into other colors. "It's like a game of telephone," she said. "You start it, but then it changes. But you can always sort of see part of your original idea. And people know that you were the first."

At Austen we are faced with the growth of an intellectual community that we do not normally see among schoolchildren. What makes the community most special is that it includes children with a wide range of personalities, interests, and learning styles who express their differences through their styles of programming.

Jeff and Kevin

In April 1981 the space shuttle is in the news, and the screens at Austen are filled with animations of space-age scenes all programmed by students: shuttle takeoffs, rocket boosters falling away, landings on terrestrial airstrips. Many of the scenes resemble each other, but you can't tell how they were programmed from how they look, or what doing it meant to the children who made them.

Jeff, a fourth grader, has a reputation as one of the school's computer experts. He is meticulous in his study habits, does superlative work in all subjects. His teachers were not surprised to see him excelling in programming. Jeff approaches the machine with determination and the need to be in control, the way he approaches both his schoolwork and his extracurricular activities. He likes to be, and often is, chairman of student committees. At the moment, his preoccupation with computers is intense: "They're the biggest thing in my life right now." He speaks very fast, and when he talks about his programs he speaks even faster, tending to monologue. He answers a question about what his program does by tossing off lines of computer code that for him seem to come as naturally as English. His typing is expert—he does not look at the code as it appears on the screen. He conveys the feeling that he is speaking directly to an entity inside. "When I program I put myself in the place of the sprite. And I make it do things."

Jeff is the author of one of the first space-shuttle programs. He does it, as he does most other things, by making a plan. There will be a rocket, boosters, a trip through the stars, a landing. He conceives the program globally; then he breaks it up into manageable pieces. "I wrote out the parts on a big piece of cardboard. I saw the whole thing in my mind just in one night, and I couldn't wait to come to school to make it work." Computer scientists will recognize this global "top-down," "divide-and-conquer" strategy as "good programming style." And we all recognize in Jeff someone who conforms to our stereotype of a "computer person" or an engineer—someone who would be good with machines, good at science, someone organized, who approaches the world of things with confidence and sure intent, with the determination to make it work.

Kevin is a very different sort of child. Where Jeff is precise in all of his actions, Kevin is dreamy and impressionistic. Where Jeff tends to try to impose his ideas on other children, Kevin's warmth, easygoing nature, and interest in others make him popular. Meetings with Kevin were often interrupted by his being called out to rehearse for a school play. The play was *Cinderella*, and he had been given the role of Prince Charming. Kevin comes from a military family; his father and grandfather were both in the Air Force. But Kevin has no intention of following in their footsteps. "I don't want to be an army man. I don't want to be a fighting man. You can get killed." Kevin doesn't like fighting or competition in general. "You can avoid fights. I never get anybody mad—I mean, I try not to."

Jeff has been playing with machines all his life—Tinkertoys, motors, bikes—but Kevin has never played with machines. He likes stories, he likes to read, he is proud of knowing the names of "a lot of different trees." He is artistic and introspective. When Jeff is asked questions about his activities, about what he thinks is fun, he answers in terms of how to do them right and how well he does them. He talks about video games by describing his strategy breakthroughs on the new version of Space Invaders: "Much harder, much trickier than the first one." By contrast, Kevin talks about experiences in terms of how they make him feel. Video games make him feel nervous, he says. "The computer is better," he adds. "It's easier. You get more relaxed. You're not being bombarded with stuff all the time."

Kevin too is making a space scene. But the way he goes about it is not at all like Jeff's approach. Jeff doesn't care too much about the detail of the form of his rocket ship: what is important is getting a complex system to work together as a whole. But Kevin cares more about the aesthetics of the graphics. He spends a lot of time on the shape of his rocket. He abandons his original idea ("It didn't look right against the stars") but continues to "doodle" with the scratchpad shape-maker. He works without plan, experimenting, throwing different shapes onto the screen. He frequently stands back to inspect his work, looking at it from different angles, finally settling on a red shape against a black night—a streamlined, futuristic design. He is excited and calls over two friends. One admires the red on the black. The other says that the red shape "looks like fire." Jeff happens to pass Kevin's machine on the way to lunch and automatically checks out its screen, since he is always looking for new tricks to add to his toolkit for building programs. He shrugs. "That's been done." Nothing new there, nothing technically different, just a red blob.

Everyone goes away and Kevin continues, now completely taken up by the idea that the red looks like fire. He decides to make the ship white so that a red shape can be red fire "at the bottom." A long time is spent making the new red fireball, finding ways to give it spikes. And a long time is spent adding detail to the now white ship. With the change of color, new possibilities emerge: "More things will show up on it." Insignias, stripes, windows, and the project about which Kevin is most enthusiastic: "It can have a little seat for the astronaut." When Jeff programs he puts himself in the place of the sprite; he thinks of himself as an abstract computational object. Kevin says that, as he works, "I think of myself as the man inside the rocket ship. I daydream about it. I'd like to go to the moon."

By the next day Kevin has a rocket with red fire at the bottom. "Now I guess I should make it move . . . moving and wings . . . it should have moving and wings." The wings turn out to be easy, just some more experimenting with the scratchpad. But he is less certain about how to get the moving right.

Kevin knows how to write programs, but his programs emerge —he is not concerned with imposing his will on the machine. He is concerned primarily with creating exciting visual effects and allows himself to be led by the effects he produces. Since he lets his plans change as new ideas turn up, his work has not been systematic. And he often loses track of things. Kevin has lovingly worked on creating the rocket, the flare, and a background of twinkling stars. Now he wants the stars to stay in place and the rocket and the flare to move through them together.

It is easy to set sprites in motion: just command them to an initial position and give them a speed and a direction. But Kevin's rocket and red flare are two separate objects (each shape is carried by a different sprite) and they have to be commanded to move together at the same speed, even though they will be starting from different places. To do this successfully, you have to think about coordinates and you have to make sure that the objects are identified differently so that code for commanding their movement can be addressed to each of them independently. Without a master plan Kevin gets confused about the code numbers he has assigned to the different parts of his program, and the flare doesn't stay with the rocket but flies off with the stars. It takes a lot of time to get the flare and the ship back together. When Jeff makes a mistake, he is annoyed, calls himself "stupid," and rushes to correct his technical error. But when Kevin makes an error, although it frustrates him he doesn't seem to resent it. He sometimes throws his arms up in exasperation: "Oh no, oh no. What did I do?" His fascination with his effect keeps him at it.

In correcting his error, Kevin explores the system, discovering new special effects as he goes along. In fact, the "mistake" leads him to a new idea: the flare shouldn't go off with the stars but should drop off the rocket, "and then the rocket could float in the stars." More experimenting, trying out of different colors, with different placements of the ship and the flare. He adds a moon, some planets. He tries out different trajectories for the rocket ship, different headings, and different speeds; more mistakes, more standing back and admiring his evolving canvas. By the end of the week Kevin too has programmed a space scene.

Styles of Mastery

Jeff and Kevin represent cultural extremes. Some children are at home with the manipulation of formal objects, while others develop their ideas more impressionistically, with language or visual images, with attention to such hard-to-formalize aspects of the world as feeling, color, sound, and personal rapport. Scientific and technical fields are usually seen as the natural home for people like Jeff; the arts and humanities seem to belong to the Kevins.

Watching Kevin and Jeff programming the same computer shows us two very different children succeeding at the same thing —and here it must be said that Kevin not only succeeded in creating a space scene, but, like Jeff, he learned a great deal about computer programming and mathematics, about manipulating angles, shapes, rates, and coordinates. But although succeeding at the same thing, they are not doing it the same way. Each child developed a distinctive style of mastery—styles that can be called "hard mastery" and "soft mastery."[7]

Hard mastery is the imposition of will over the machine through the implementation of a plan. A program is the instrument of premeditated control. Getting the program to work is more like getting "to say one's piece" than allowing ideas to emerge in the give-and-take of conversation. The details of the specific program obviously need to be "debugged"—there has to be room for change, for some degree of flexibility in order to get it right—but the goal is always getting the program to realize the plan.

Soft mastery is more interactive. Kevin is like a painter who stands back between brushstrokes, looks at the canvas, and only from this contemplation decides what to do next. Hard mastery is the mastery of the planner, the engineer, soft mastery is the mastery of the artist: try this, wait for a response, try something else, let the overall shape emerge from an interaction with the medium. It is more like a conversation than a monologue.

Hard and soft mastery recalls anthropologist Claude Lévi-Strauss' discussion of the scientist and the *bricoleur*.[8] Lévi-Strauss used the term *bricolage*, tinkering, to make a distinction between Western science and the science of preliterate societies. The former is a science of the abstract, the latter is a science of the concrete. Like the *bricoleur*, the soft master works with a set of concrete elements. While the hard master thinks in terms of global abstractions, the soft master works on a problem by arranging and rearranging these elements, working through new combinations. Although the *bricoleur* works with a closed set of materials, the results of combining elements can lead to new and surprising results.

Mastery and Personality

Computer programming is usually thought of as an activity that imposes its style on the programmer. And that style is usually presumed to be closer to Jeff and his structured, "planner's" approach than to Kevin and his open, interactive one. In practice, computer programming allows for radical differences in style. And looking more closely at Jeff and Kevin makes it apparent that a style of dealing with the computer is of a piece with other things about the person—his or her way of facing the world, of coping with problems, of defending against what is felt as dangerous.[*] Programming style is an expression of personality style.

---

[*] Not all computer systems, not all computer languages offer a material that is flexible enough for differences in style to be expressed. A language such as BASIC does not make it easy to achieve successful results through a variety of programming styles. This does not

For example, the hard masters tend to see the world as something to be brought under control. They place little stock in fate. In child's terms, they don't believe much in a rabbit's foot or a lucky day. Jeff is popular and sociable, but he likes to be committee chairman, the one who controls the meeting. From the earliest ages most of these children have preferred to operate on the manipulable—on blocks, on Tinkertoys, on mechanisms. It is not surprising that the "hards" sometimes have more difficulty with the give-and-take of the playground. When your needs for control are too great, relationships with people become tense and strained. The computer offers a "next-best" gratification. The Tinkertoy is inert. The computer is responsive. Some children even feel that when they master it they are dominating something that "fights back." It is not surprising that hard masters take avidly to the computer. It is also not surprising that their style of working with the computer emphasizes the imposition of will.

The soft masters are more likely to see the world as something they need to accommodate to, something beyond their direct control. In general, these children have played not with model trains and Erector sets but with toy soldiers or with dolls. They have taken the props (cowboy hats, guns, and grownup clothes for dress-up) from the adult world and used them in fantasy play with other children. In doing so, they have learned how to negotiate, compromise, empathize. They tend to feel more impinged upon, more reactive. As we have seen, this accommodating style is expressed in their relational attitude toward programming as well as in their relationships with people.

Very young children find the computer evocative because it seems to stand betwixt and between the world of alive and not alive. The sprite, the computational object that is there to command on the screen, is also evocative. It stands between the world of physical objects and the world of abstract ideas. Ambivalent in its nature, it is taken up differently by the hard and soft masters, the hard masters treating it more like an abstract entity—a Newtonian particle—the soft masters treating it more as a

---

make BASIC any less adequate as a computer language. It means that it provides a less malleable material for different styles of use. In the Austen School the conditions were right for a wide variety of children to form very different relationships with programming. The environment allowed freedom to experiment, and the computer system was designed to go further than most in allowing for a diversity of approaches.

physical object: a dab of paint, a building block, a cardboard cut-out.

Jeff sees the system of Logo sprites as a formal system, something apart from his everyday life. He identifies with an abstract piece of it. He objectified the sprite, saw it as a thing apart, and then put himself in its place in order to command its actions. Jeff said, "I'm a sprite in there." The soft master identifies differently. Kevin did not objectify the sprite, he did not become the abstract thing—he took who he feels himself to be and entered a new world of make-believe. He said, "I'm me in there, driving the spaceship." Identification is not for an instrumental purpose, but in the service of fantasy.

Psychologist David Shapiro has used the idea of "neurotic styles" to capture what each of us intuitively knows about him- or herself: we are the same person whether we are solving an intellectual problem or sorting out a personal difficulty. And, indeed, the blocks we run into, the ways we achieve or avoid success in the cognitive and affective domains, often take us aback by their similarity. The use of clinical categories to describe these styles reflects the fact that when we look at human psychology there is a continuum between what we see as ill and what we see as normal. The underlying processes are the same for everyone; some simply suffer from them more than others. Thus we come to understand ourselves better by knowing what we would be like if the stresses of life led us to a breaking point. At that breaking point, our "neurotic style" would be transformed into a disabling symptom. At that point, the style "takes over," severely limiting our ability to cope with reality. Before that point, a neurotic style is simply a way of approaching the world and of defending oneself against what is painful.

Shapiro describes an obsessive-compulsive style in terms that recall the relationship of the hard masters with their machines. He speaks of the obsessive-compulsives' intense and sharply focused attention and their interest in technical details. Like Jeff who was interested in only one thing when he looked at the other children's programs (was there any new technical stuff?), Shapiro's prototypical obsessive-compulsive may listen to a recording with the keenest interest in the equipment "but hardly hear . . . the music."[9]

On the other hand, Shapiro describes a hysterical style in terms that recall the soft master. When obsessive-compulsives are asked a question, they give a sharp and detailed technical answer. Hysterics respond with impressions; their interest is global: ". . . many times in connection with the mathematics problems on an intelligence test, hysterical subjects are unable to reproduce the processes by which they arrived at their answers . . . even if the answers are correct."[10]

Our approach to the world is profoundly marked by the ways we defend ourselves. Different personality styles rely on a characteristic set of defense mechanisms. Shapiro's "obsessives" rely on selective inattention, rigidity, and radical simplification. They tend to see things in black and white. In their emotional lives the "hard masters" are practiced in creating reductive models of the complex. In their intellectual lives they do so as well. In many ways, the hard masters' black and white representations of everyday life (Jeff talks about the friends he loves and the former friends he hates) are similar to their formalized representations of objects. Objectifying and identifying with a sprite or a pulley or a Newtonian particle—all of these useful simplifications for doing science and for dealing with formal systems—fit in with a tendency to simplify people and events. Both come easily. But, of course, Jeff's style of objectifying and identifying with objects—with the gear of the bicycle, the sprite on the screen—is easier and more natural for some people than for others.

The "softs," Shapiro's hysterics, deal with pain by forgetting it or through an impressionistic blurring of sharp lines. They often have particular trouble and indeed balk at the very idea of what they see as "reductive identification." Not for them the reduction of the world into black and white or the simplification of reality through abstraction. They can't identify with abstract particles, they can only identify with other persons. Not only are the softs less practiced in formal representation, but for them such representations can feel threatening.

In all of this, the computer acts as a Rorschach, allowing the expression of what is already there. But it does more than allow the expression of personality. It is a constructive as well as a projective medium. For example, it allows "softs" such as Kevin to operate in a domain of machines and formal systems that has been thought to be the exclusive cultural preserve of the "hards." For the first time Kevin could march into a mathematical world with hysterical colors flying full mast.

Mastery and Gender

I have used boys as examples in order to describe hard and soft mastery without reference to gender. But now it is time to state what might be anticipated by many readers: girls tend to be soft masters, the hard masters are overwhelmingly male. At Austen, girls are trying to forge relationships with the computer that bypass objectivity altogether. They tend to see computational objects as sensuous and tactile and relate to the computer's formal system not as a set of unforgiving "rules," but as a language for communicating with, negotiating with, a behaving, psychological entity.

There are many reasons why we are not surprised that girls tend to be soft masters. In our culture girls are taught the characteristics of soft mastery—negotiation, compromise, give-and-take—as psychological virtues, while models of male behavior stress decisiveness and the imposition of will. Boys and girls are encouraged to adopt these stances in the world of people. It is not surprising that they show up when children deal with the world of things. The girl child plays with dolls, imagined not as objects to command but as children to nurture. When the boy unwraps his birthday presents they are most likely to be Tinkertoys, blocks, Erector sets—all of which put him in the role of builder.

Thinking in terms of dolls and Erector sets, like talking about teaching negotiation and control, suggests that gender differentiation is a product of the social construction that determines what toys and what models of correct behavior are given to children of each sex. Psychoanalytic thought suggests many ways in which far earlier processes could have their role to play; styles of mastery may also be rooted in the child's earliest experiences. One school of thought, usually referred to as "object relations theory," is particularly rich in images that suggest a relation between styles of mastery and gender differences.

It portrays the infant beginning life in a closely bonded relationship with the mother, one in which boundaries between self and other are not clear. Nor does the child experience a separation between the self and the outer world.[11] The gradual development of a consciousness of separate existence begins with a separation from the mother. It is fraught with conflict. On the one hand, there is a desire to return to the comfort of the lost state of oneness. On the other hand, there is the pleasure of autonomy, of acting on independent desire. Slowly the infant develops the sense of an "objective" reality "out there" and separate from the self. Recently, there has been serious consideratin of the ways in which this process may take on a sense of gender. Since our earliest and most compelling experiences of merging are with the mother, experiences where boundaries are not clear become something "female." Differentiation and delineation, first worked through in a separation from the mother, are marked as "not-mother," not-female.

Up to this point the experiences are common to girls and boys. But at the Oedipal stage, there is a fork in the road. The boy is involved in a fantasized romance with the mother. The father steps in to break it up and, in doing so, strikes another blow against fusional relationships. It is also another chance to see the pressure for separation as male. This is reinforced by the fact that this time the boy gives up the idea of a romance with the mother through identifying himself with his father. Thus, for the boy, separation from the mother is more brutal, because in a certain sense it happens twice: first in the loss of the original bonded relationship, then again at the point of the Oedipal struggle.

Since separation from the mother made possible the first experiences of the world as "out there," we might call it the discovery of the "objective." Because the boy goes through this separation twice, for him objectivity becomes more highly charged. Boys feel a greater desire for it: the objective, distanced relationship feels like safe, approved ground. There is more of a taboo on the fusional, along with a correspondingly greater fear of giving in to its forbidden pleasures. According to this theory the girl is less driven to objectivity because she is allowed to maintain more elements of the old fusional relationship with the mother, and, correspondingly, it is easier for her to play with the pleasures of closeness with other objects as well.[12]

Anne and Mary

In the eyes of a true hard programmer like Jeff, his classmate Anne, also nine, is an enigma. On the one hand, she hardly seems serious about the computer. She is willing to spend days creating shimmering patterns on the screen in a kind of "moiré effect" and she doesn't seem to care whether she gets her visual effects with what Jeff would classify as technically uninteresting "tricks" or with what he would see as "really interesting" methods. Jeff knows that all the children anthropomorphize the computer to a certain extent; everyone says things like "My program knows how to do this" or "You have to tell the computer what speed you want the sprites to go," but Anne carries anthropomorphizing to what, to Jeff, seems like extreme lengths. For example, she insists on calling the computer "he," with the explanation "It doesn't seem right to call it an it." All the same, this doesn't keep her from getting down to serious programming. She has made some technical inventions, and Jeff and the other male hard masters recognize that if they want to keep abreast of the state of the art at Austen they must pay attention to what Anne is doing. And Anne knows how to take advantage of her achievements. She analogizes the spread of programming ideas to the game of telephone and enjoys seeing versions of her ideas on half a dozen screens. "They didn't copy me exactly, but I can recognize my idea." Jeff's grudging acknowledgment of Anne's "not quite serious" accomplishments seems almost a microcosm of reactions to competent women in society as a whole. There, as at Austen, there is appreciation, incomprehension, and ambivalence.

When Jeff talks with the other male experts about the computer, they usually talk "shop" about technical details. Anne, on the other hand, likes to discuss her strong views about the machine's psychology. She has no doubt that computers have psychologies: they "think," as people do, although they "can't really have emotions." Nevertheless, the computer might have preferences. "It would like it if you did a pretty program." When it comes to technical things, she assumes the computer has an aesthetic: "I don't know if it would rather have the program be very complicated or very simple."

He

he

Anne thinks about whether the computer is alive. She says that the computer is "certainly not alive like a cat," but it is "sort of alive," it has "alive things." Her evidence comes from the machine's responsive behavior. As she types her instructions into the machine, she comments, "You see, this computer is close to being alive because he does what you are saying."

This remark is reminiscent of the talk among the somewhat younger children who were preoccupied with sorting out the com-

BEST COPY

puter's status as a living or a not living thing. There is, however, a difference. For the younger children, these questions have a certain theoretical urgency. For Anne, they are both less urgent and part of a practical philosophy: she has woven this way of seeing the computer into her style of technical mastery.

Anne wants to know how her programs work and to understand her failures when they don't. But she draws the line between understanding and not understanding in a way that is different from most of the hard-master boys at a similar degree of competence. For them, a program (like anything else built out of the elements of a formal system) is either right or wrong. Programs that are correct in their general structure are not "really correct" until the small errors, the bugs, are removed. For a hard programmer like Jeff, the bugs are there to ferret out. Anne, on the other hand, makes no demand that her programs be perfect. To a certain degree, although to put it too flatly would be an exaggeration, when she programs the computer she treats it as a person. People can be understood only incompletely: because of their complexity, you can expect to understand them only enough to get along, as well as possible for maintaining the kind of relationship you want. And when you want people to do something, you don't insist that it be done exactly as you want it, but only "near enough." Anne allows a certain amount of negotiation with the computer about just what should be an acceptable program. For her, the machine is enough alive to deserve a compromise.

This "negotiating" and "relational" style is pervasive in Anne's work but is more easily described by an example from her classmate Mary, another soft-mastery programmer and an even stauncher lobbyist for the use of personal pronouns to refer to computers. Mary differs strikingly from Anne in having a soft style that is verbal where Anne's is consistently visual.

Mary wanted to add a few lines of dialogue to the end of a game program. Her original idea was that the computer would ask the player, "Do you want to play another game?" If the player typed "Yes," a new game would start. If the player typed "No," the machine would print out the final score and "exit" the program—that is, put the machine back into a state where it is ready for anything, back to "top level." She writes a program that has two steps, captured in the following English-language rendition of the relevant Logo instructions:

If what-the-user-types is "Yes," start a new game.

If what-the-user-types is "No," print score and stop.

As instructions to an intelligent person, these two statements are unambiguous. Not so as instructions to a computer. The program "runs," but not quite as Mary originally planned. The answer "Yes" produces the "right" behavior, a new game. But in order to get the final score and exit, it is necessary to type "No" twice. Mary knew this meant there was an "error," but she liked this bug. She saw the behavior as a humanlike quirk.

What was behind the quirk? The computer is a serial machine; it executes each instruction independently. It gets up to the first instruction that tells it to wait until the user types something. If this something is "Yes," a new game is started up. If the user doesn't type "Yes," if, for example, he or she types "No," the computer does nothing except pass on to the next instruction without "remembering" what has come before. The second instruction, like the first, tells the computer to wait until the user has typed something. And if this something is "No," to print the score and stop.

Now the role of the two "Nos" is clear. A single "No" will leave the computer trying to obey the second instruction—that is, waiting for the user to type something. There are ways of fixing this bug, but what is important here is the difference in attitude between a programmer like Jeff, who would not rest until he fixed it, and a programmer like Mary, who could figure out how to fix it but decides not to. Mary *likes* this bug because it makes the machine appear to have more of a personality. It lets you feel closer to it. As Mary puts it, "He will not take no for an answer" unless you really insist. She allows the computer its idiosyncrasies and happily goes on to another program.

Mary's work is marked by her interest in language. Anne's is equally marked by her hobby, painting. She uses visual materials to create strategies for feeling "close to the machine."

Anne had become an expert at writing programs to produce visual effects of appearance and disappearance. In one, a flock of birds flies through the sky, disappears at the horizon and reappears some other place and time. If all the birds are the same color, such as red, then disappearance and appearance could be produced by the commands "SETCOLOR :INVISIBLE" to get rid of them and "SETCOLOR :RED" to make them appear. But since Anne wants the birds to have different colors, the problem of the birds reappearing with their original color is more complicated.

There is a classical method for getting this done: get the program to "store away" each bird's original color before changing that color to "invisible," and then to recall the color when the birds are to reappear. This method calls for an algebraic style of thinking. You have to think about variables and use a variable for each color—for example, letting A equal the color of the first bird, B the color of the second bird, and so on. Anne will use this kind of method when she has to, but she prefers another kind, a method of her own invention that has a different feel.

bird

She likes to feel that she is there among her birds, manipulating them much in the way she can manipulate physical materials. When you want to hide something on a canvas, you paint it out, you cover it with something that looks like the background. This is Anne's solution. She lets each bird keep its color, but she makes her program "hide it" by placing a screen over it. She designs a sprite that will screen the bird when she doesn't want it seen, a sky-colored screen that makes it disappear. Just as the computer can be programmed to make a bird-shaped object on the screen, it can be programmed to make an opaque sky-colored square act as a screen.

Anne is programming a computer, but she is thinking like a painter. She is not thinking about sprites and variables. She is thinking about birds and screens. Anne's way of making birds appear and disappear doesn't make things technically easy. On the contrary, to maintain her programming aesthetic requires technical sophistication and ingenuity.*

For example, how does the program "know" where the bird is so as to place the screen on it? Anne attaches the screen to the bird when the bird is created, instead of putting it on later. The screen is on top of the bird at all times and moves with the bird wherever it goes. Thus she has invented a new kind of object, a "screened bird." When Anne wants the bird to be seen, the screen is given the "invisible" color, so the bird, whatever its color, shows right through it. When she wants the bird to disappear, the screen is given the color of the sky. The problem of the multiplicity of bird colors is solved. A bird can have any color. But the screens need only two colors, invisible or sky blue. A bird gets to keep its color at all times. It is only the color of its screen that changes. The problem of remembering the color of a particular bird and reassigning it at a particular time has been bypassed.

---

* The idea of a screened bird makes unusual use of a feature of the Logo system where moving objects are built out of screen sprites, each of which can be thought of as a mobile frame about half an inch square. On each sprite you can draw a picture. Large objects such as Jeff and Kevin's rocket ships are made by placing sprites side by side to make a large picture. Anne's birds are small enough to be drawn on a single sprite. Her innovation consisted of using two sprites (one for the screen, one for the bird) and placing them one on top of the other so that they occupy the same space, rather than side by side. To make them move together as a single object, she applied the techniques Jeff and Kevin used for keeping their compound objects together, but instead of thinking of the compound objects as a way of getting more size, Anne thinks of them as a way of getting more complexity of behavior.

Anne's bird program is particularly ingenious, but its programming style is characteristic of many of the girls in her class. Most of the boys seem driven by the pleasures of mastering and manipulating a formal system: for them, the operations, the programming instructions, are what it is all about. For Anne, pleasure comes from being able to put herself into the space of the birds. Her method of manipulating screens and birds allows her to feel that these objects are close, not distant and untouchable things that need designation by variables. The ambivalence of the computational sprite—an object at once physical and abstract—allows it to be picked up differently by hards and softs. Anne responds to the sprites as physical objects. Her work with them is intimate and direct. The formal operations need to be mastered, but they are not what drive her.

No one would find Anne's relation to the birds and the screens surprising if it were in the context of painting or making collages with scraps of this and that. There we expect to find "closeness to the object." But finding a sensual aesthetic in the development of a computer program surprises us. We tend to think of programming as the manipulation of a formal system which, like the objects for scientific inquiry, is "out there" to be operated on as something radically split from the self.

Gender and Science

Evelyn Keller has coined the phrase "the genderization of science." She argues that what our culture defines as the scientific stance toward the world corresponds to the kind of relationships with the object world that most men (if we follow psychoanalytic theories of development) would be expected to find most comfortable.[13] It is a relationship that cuts off subject from object.

Scientific objects are placed in a "space" psychologically far away from the world of everyday life, from the world of emotion and relationships. Men seem able, willing, and invested in constructing these separate "objective" worlds, which they can visit as neutral observers. In this way the scientific tradition that takes objectivity as its hallmark is also defined as a male preserve. Taking it from the other side, we can see why men would be drawn to this construction of science. Men are highly invested in objective relationships with the world. Their earliest experiences have left them with a sense of the fusional as taboo, as something to be defended against. Science, which represents itself as revealing a reality in which subject and object are radically separated, is reassuring. We can also see why women might experience a conflict between this construction of science and what feels like "their way" of dealing with the world, a way that leaves more room for continuous relationships between self and other. Keller adds that the presentation of science as an extreme form of objective thinking has been reinforced by the way in which male scientists traditionally write and speak about their work. A characterization of science that appears to "gratify particular emotional needs" may "give rise to a self-selection of scientists—a self-selection which would in turn lead to a perpetuation of that characterization."[14]

In Anne's classroom, nine- and ten-year-old girls are just beginning to program. The fact that they relate to computational objects differently from boys raises the question of whether with growing expertise they will maintain their style or whether we are simply seeing them at an early stage before they become "recuperated" into a more objective computational culture. In my observation, with greater experience soft masters, male and female, reap the benefits of their long explorations, so that they appear more decisive and more like "planners" when they program on familiar terrains. But even there the "negotiating" and "relational" style is still present behind the appearance.

Lorraine is the only woman on a large team working on the

/remains

/ and researchers [illegible] tackle [illegible] design of a new programming language. She expresses her sense of difference with some embarrassment.

> I know that the guys I work with think I am crazy. But we will be working on a big program and I'll have a dream about what the program feels like inside and somehow the dream will help me through.
>
> When I work on the system I know that to everybody else it looks like I'm doing what everyone else is doing, but I'm doing that part with only a small part of my mind. The rest of me is imagining what the components feel like. It's like doing my pottery. . . . Keep this anonymous. I know this sounds stupid.

Shelley is a graduate student in computer science who corrects me sharply when I ask her when she got interested in electronics and machines. "Machines," she responds, "I am definitely not into machines." And she is even less involved with electronics:

> My father was an electrician and he had all of these machines around. All of these wires, all of this stuff. And he taught my brothers all about it. But all I remember him telling me was, "Don't touch it, you'll get a shock." I hate machines. But I don't think of computers as machines. I think of moving pieces of language around. Not like making a poem, the way you would usually think of moving language around, more like making a piece of language sculpture.

These words are reminiscent of women in other scientific disciplines. Barbara McClintock, an eminent biologist, describes her work as an ongoing "conversation" with her materials, and she speaks of frustration with the way science is usually done: "If you'd only just let the materials speak to you . . ."[15] In an interview with her biographer, Evelyn Keller, McClintock described her studies of neurospora chromosomes (so small that others had been unable to identify them) in terms that recall Anne's relationship with the birds and the screens. "The more she worked with the chromosomes, the bigger they got, until finally, 'I wasn't outside, I was down there—I was part of the system.' . . . As 'part of the system' even the internal parts of the chromosomes become visible. 'I actually felt as if I were down there and these were my friends.' "[16]

Keller comments that McClintock's "fusion" with her objects of study is something experienced by male scientists. But perhaps McClintock was able to exploit this less distanced model of scientific thought, far from the way science was discussed in the 1950s, more fully, visibly, and less self-consciously, because she is a woman. This is surely the case for the girls in the Austen classrooms. Their artistic, interactive style is culturally sanctioned. Of course, with children, as in the larger world, the lines of division are not rigid. Some girls are hard masters and I purposely took a boy as the first case of a soft master—Kevin, who did not see the sprites as "outside" but who is right there with them, who imagines himself a traveler in the rocket ship, taking himself and his daydreams with him.

Children working with computers are a microcosm for the larger world of relations between gender and science. Jeff took the sprite as an object apart and in a world of its own. When he entered the sprite world, it was to command it better. Kevin used the sprite world to fantasize in. Anne does something more. She moves further in the direction I am calling "feminine," further in the direction of seeing herself as in the world of the sprite, further in the direction of seeing the sprite as sensuous rather than abstract. When Anne puts herself into the sprite world, she imagines herself to be a part of the system, playing with the birds and the screens as though they were tactile materials.

Science is usually defined in the terms of the hard masters: it is the place for the abstract, the domain for a clear and distinct separation between subject and object. If we accept this definition, the Austen classroom, with its male hard masters, is a microcosm of the male genderization of science. But what about Anne and Mary? What about the other girls like them who are exploring and mastering the computer? Should we not say that they too are "little scientists"? If we do, then we see at Austen not only a model of the male model that characterizes "official science," but a model of how women, when given a chance, can find another way to think and talk about the mastery not simply of machines but of formal systems. And here the computer may have a special role. It provides an entry to formal systems that is more accessible to women. It can be negotiated with, it can be responded to, it can be psychologized.

The computer sits on many borders; it is a formal system that can be taken up in a way that is not separate from the experience of the self. As such, it may evoke unconscious memories of objects that lie for the child in the uncertain zone between self and not-self. These are the objects, like Linus' baby blanket, the tattered rag doll, or the bit of silk from a first pillow, to which children remain attached even as they embark on the exploration of the world beyond the nursery. Psychoanalytic theorists call these objects "transitional" because they are thought to mediate between the child's closely bonded relationship with the mother and his or her capacity to develop relationships with other people who will be experienced as separate, autonomous beings.[17] They are experienced as an almost inseparable part of the infant and the first not-me possession. As the child grows, the actual objects are discarded, but the experience of them remains diffused in the intense experiencing throughout life of an intermediate space. Music and religious experience share with the early transitional objects the quality of being felt simultaneously from within and from without.[18] So do creative moments in science and mathematics.

The idea of "formality" in scientific thought implies a separateness from the fuzzy, imprecise flow of the rest of reality. But using a formal system creatively, and still more, inventing it, requires it to be interwoven with the scientist's most intuitive and metaphorical thinking. In other words, it has to be mastered in a soft form.

So, in addition to suggesting a source of the computer's holding power, women's relationships with computational objects and the idea of the transitional object may illuminate the holding power of formal systems for people who are in the closest contact with them. Even for the hard masters, the "feminine" may be the glue that bonds.[19]

Mathematics for "Softs"

Many of us know mathematics only as an alien world designed by and for people different from us. The story of a third-grader named Ronnie may be a portent of how computers in children's lives can serve as a bridge across what we have come to accept as a two-culture divide. For Ronnie, as for the soft masters Anne and Kevin, building this bridge depends on the ability to identify physically with the sprites on the computer screen. The accessibility of the formal system depended on its having hooks in the world of the sensual.

Ronnie is eight years old and black; his family has recently moved to Boston from a rural town in South Carolina. He comes

ill

to school with a radio and dances to its beat. He climbs all over my colleague as he works with him at the computer. Ronnie is filled with stories—stories about his father's adventures as a policeman, about visits to his grandmother's farm down South, about the personalities of the baby chicks in his classroom. His favorite story is about the day his pet gerbil escaped, a story I get to hear many times, more elaborate, more embroidered, each time. The stories, like his physical closeness, are his way of making contact, of forging friendships, of drawing others into his life.

Ronnie is bright and energetic but he is doing badly in school. He has trouble with mathematics, with grammar, with spelling, with everything that smacks of being a formal system. In a way that is characteristic of the hysterical style described by Shapiro, he is impatient with anything that involves precise and inflexible rules, yet he enjoys his work with the computer although its rules are no less precise and inflexible. He is working with a program called "EXPLODE." In this program, the thirty-two Logo sprites are given the shape of colored balls and are stacked in the center of the screen—so that at the beginning you see only one sprite, the "one on top." The sprites are all assigned the same speed, but each has a different heading so that they move out in an expanding circle until a certain time has elapsed (the Logo system will also accept "time commands," for example to "wait 10 seconds"), at which point the circle implodes. The balls move back to the center, and the cycle repeats. The effect is a pulsating dance of color, to which Ronnie responds by dancing, too, and by making up little songs to accompany the pace of the explosion. But unlike the music on his radio, the beat of the computer dance can be modified. The pattern of the movement is determined by commands of speed and time. At speed forty, the speed at which the balls are set when he meets the program, the balls go halfway to the edge of the screen before falling back.

Ronnie has become very involved in the dance of the colored balls. He experiments with the different effects he can achieve by pressing the "home" key before the balls have come to the end of their travels. When he does this the balls travel a shorter distance and he is able to speed up the cycle. He carries this line of investigation to its limit. The effect is a multicolored pulse at the center of the screen. But finally Ronnie is dissatisfied with the new pulse effect, which he calls "drumbeat." He wants the dance to be "perfect," saying, "I dance perfect. I want them to dance perfect." At first, I don't understand. "Perfect" turns out to mean something very specific: "The balls should go right to the edge." He wants them to travel *exactly* to the outer reaches of the screen before falling back.

Ronnie has never heard the term "variable," and it would be nearly impossible to explain it to him. But he has experimented enough to understand that to get the perfect dance he has to change the speed at which the balls fly out and the time of their flight before they return. So, without having the words to express precisely what he does, Ronnie works with two variables in order to control the spatial and temporal pattern of the explosion.

At first he does not know how to change the numbers that control speed and time. A speed of forty gets halfway to the edge. What would get all the way? Forty-one, thirty-nine, two thousand? All of these are tried and their effects intently observed. Nor does he know how to change the "time variable" that instructs the balls to fly out for a given number of seconds and then return to their starting place. Ronnie's mode of interaction with this program consists of trying different things, watching how they work out, dancing to the new rhythms, and then stepping back to make further attempts to make the patterns more satisfying by changing one or the other of the variables. Eventually, Ronnie brings the program under control. He has arrived at a combination of speed and time for the "perfect" explosion. Not only does he have a pair of numbers, but he has a principle. To make the tempo slower you increase the time, but in order to get the balls to go to the same place you have to decrease their speed. Understanding this relationship means that he can now get the tempo he wants and also get the balls to the edge of the screen. He can dance to the right beat and he can have the visual effect that matches the perfection of his dancing.

In the course of a long afternoon, Ronnie has learned how to work a little formal system, one that some people might learn in the section of the algebra curriculum called "rates, times, and distances." But Ronnie might never have gotten there, for the standard route to algebra lies through many hours of a different kind of activity: sitting still at a desk, filling numbers into squares, manipulating equations on paper. Some people like this kind of activity. Jeff, the master-planner computer expert, loves it—because it is structured, because of its fine detail, because it imposes an order by the manipulation of rules and the adherence to constraints. The difference between Ronnie and Kevin and a child like Jeff, who truly enjoys the experience of school math, is not simply one of "numerical ability." It is something more general, a difference of personality.

The conventional route to mathematics learning closes doors to many children whose chief way of relating to the world is through movement, intuition, visual impression, the power of words, or of a "beat."[30] In some small way that may prove important to our culture as a whole, computers can open some of these doors.

Tanya and a World of Words

The computer put Ronnie in contact with a mathematical experience. For Tanya, another black student, it mediated a first experience with writing.

Tanya's fifth-grade school record looks bleak: it reports that she can't spell, can't add or subtract, doesn't write. It gives no hint of what is most striking when you meet her: Tanya has a passionate interest in words and the music of speech. "I go by the word of the Lord, the word of the Bible. If you have the deep down holy ghost and you are speaking in the tongue which God has spoke through you, you harken to the word." As Tanya speaks, she wraps herself in a rich world of language. She speaks of apocalypse, salvation, and sin. "You think that just because you get burned by fire, that you know what fire is, but it ain't like that honey, because when you go to hell, you gonna burn, you gonna burn, you gonna burn . . ." The school language of readers and workbooks and sample sentences cannot compete with Tanya's flowing, tumbling discourse. She says "school is not a good place for my kind of words."

Holy Ghost

H / g

[illegible]

In fifth grade, her teachers, concerned that she had never written anything, tried to get her to "write" by asking her to say sentences about people she knew in order to make a "storybook." The teacher would recast each sentence to make it grammatical. Tanya, sensitive about ruining the now "perfect" sentence with her "ugly handwriting," would not even try to write out the sentence in her own hand. The teacher did the actual writing. Tanya drew a picture. The completed storybook project contains five sentences, each a teacher's representation of something Tanya said. A typical entry from the fifth-grade storybook reads, "Dr. Rose is my dentist. I was his first patient."

In creating the storybook, the teacher was trying to give Tanya instant "feedback," but what she heard was instant judgment. The storybook became a badge not of success but of failure, something less than "perfect." "Writing," then, was exposing oneself and being found wanting.

This is where Tanya was when she met the computer at the beginning of sixth grade. The computer room where Tanya worked coutained four identical machines which Tanya personalized; she would only work with the computer she called "Peter."

> I thought the computer was gonna be like some little animal, some little tiny animal, you know, like these little toy animals. I thought it was gonna be one of those animals, you just pull a knob and it says something to you. I thought it would talk. Say hello.

From the very first day, Tanya wanted Peter to "talk" with her. She tried shouting at Peter, then used the keyboard as she was instructed, responding to the computer's error messages (YOU HAVEN'T TOLD ME HOW TO . . .) as cues to begin a dialogue: "Yes, I did tell you how to go forward 445, you fool. You are a fool. You know that. You are a fool."

Tanya's first program got Peter to "introduce" himself:

```
TO WHO
PRINT [MY NAME IS PETER]
END
```

The effect of this program is that whenever the word WHO is typed at the computer console, the machine will respond with "MY NAME IS PETER." The program delighted Tanya. She demonstrated it to everyone. But Tanya did not go very far with programming. As she was working on Peter's "WHO" program she made two discoveries that set her on another course. She discovered how to clear all text off the screen. And she discovered the delete key, the key that "erases" the last character that has been typed. For Tanya, the discoveries were as if magical: any letter could be deleted without trace or mess; anything written could be corrected, and then printed as tidily as a book. This girl who had never written before sat down at the computer and worked a whole hour on a single sentence until it was exactly to her liking. She ended up with a letter:

> DORIS
> DEAR DORIS HOW ARE YOU BEING UP IN NEW YORK. I HOPE I WILL SEE YOU IN THE SUMMER. LOVE TANYA AND PETER.

From that beginning, Tanya's only activity with the computer was writing. More letters poured forth and then stories about relatives, about people she had once met, about classmates and teachers. Tanya wrote stories about classmates she had been afraid to speak to and the presentation of her letters became first acts of friendship.

Tanya's relationship with the computer showed the intensity of the most driven programmers and the most dedicated players of video games. She would be the first in and the last out in the periods assigned for her group to work with the computers. Tanya had a personal relationship with Peter. She introduced Peter to visitors with the WHO procedure, would say things like "Take good care of Peter" when she left for the day, and signed his name alongside hers at the bottom of completed letters. On one occasion when another student got into the computer room first and sat down at "her computer," Tanya threw a fit of temper. The teacher's declaration that the computers were identical simply fueled her rage. She did not want the computers to be identical. She wanted Peter to be special, different, more than a thing, if not quite a person.

What was cause and what effect? Did the power of Tanya's relationship with the computer come from her repressed desire to write or did the intensity and the pace of her learning to write come from the special emotional force of a relationship with a computer? In either case the computer mediated a transformation of Tanya's relationship with writing. When I saw her two years after the end of the research project that had given her access to Peter she was still writing, indeed she had come to define herself as a writer. Most of her writing is poetry. "I get my poems from looking at people," Tanya tells me as she reads me her "favorite part" of a birthday poem she has written for her mother.

Cold in a rocking chair
Watching Martin Luther King's memories go by.
Sitting here yelling back and forth
Like an old grandmother with a toothache
You're bored stiff because no one's there to see your need.
You're just rocking away like an old grandmother.

Most children learn to write with the most imperfect of media: their unformed handwriting. For most it does not seriously stand in their way. For Tanya it did. She is fiercely proud of her appearance. Her clothes are carefully chosen. Her hair is artfully arranged, usually with ribbons, barrettes, and braids, changing styles from day to day. She has very clear ideas about what is beautiful and what is ugly. She saw her handwriting as ugly and unacceptable. It made writing unacceptable.

The computer offered her a product that looked "so clean and neat" that it was unquestionably right, a feeling of rightness she had never known at school, where she was always painfully aware of her deficiencies, ashamed of them, and, above all, afraid of being discovered.

Tanya saw writing as telling Peter to write. She put the computer in the role of a child and she became the teacher and the parent.

> You tell a child to go to the store and it might, but the child will say, "Ma, you didn't tell me how to get to the store. I don't know how to get there." That's the way it is with computers. Like teaching a child. But when you teach a child you remember it too. When you are with a computer you know the whole time what you are saying. You have it inside your ear. When you are using your fingers to be with Peter, using emotions with the computer.

Tanya identified with Peter's learning. It was hers. She heard it inside her "ears," felt it in her "fingers" and "emotions."

Tanya continued to grow as a writer after the computer was no longer available to her because she had developed a strong enough idea of herself as a writer to find means of practicing her art without Peter. She has developed a stylized calligraphy that makes her own handwriting more acceptable to her. And she often persuades a teacher to take dictation, but now, on the model of Peter, the teacher is not permitted to make "corrections."

When Tanya anthropomorphized Peter she created a demiperson, a "little animal" that could play the role the teacher had played when she made the storybook. The teacher wrote down what she said. So would Peter. But unlike the first teacher, Peter was a perfect scribe. He gave Tanya the possibility of creating something not ugly, but he allowed her to do it by herself, without humiliating corrections. It was in gratitude that Tanya signed her computer stories "written by Tanya and Peter." The computer was a gentle collaborator. It allowed Tanya to disassociate writing from painful self-exposure and freed her to use writing for self-expression, indeed for self-creation.

As Tanya graduates, the school library accepts her gift of a volume of her poems. For Tanya, the presence of her book in the library marks her first relationship with a larger culture, one that begins with the school and extends beyond it. In other cases, children use the computer in an effort to break out of more limited kinds of isolation.

Computers and Cultural Divides

Children like Kevin and Ronnie tend to be afraid of technical objects and develop negative relationships with science and mathematics. As they grow older, they become more defensive. An early computer experience might make a difference. Unlike arithmetic and school math drill, the computer offers a glimpse into the aesthetic dimension of mathematics and science. And, unlike arithmetic and school math, it provides an expressive medium to which soft masters are drawn. Whether or not they go on to excel in computational, mathematical, or scientific studies is an open question. But they have a point of entry, and they will not be disfranchised in a world where computers are increasingly part of everyday life. They will not feel that all of that belongs to other kinds of people.

Walls are breaking down on the other side as well. In the year that I followed his progress, Jeff had a master plan—making a video game that involved several rockets, missiles firing lasers, consequent explosions, and the disintegration of an enemy ship. Jeff kept the structure in mind as he sought ways to achieve particular effects, assimilating what he needed to know (for example, about Cartesian coordinates and their implementation on the computer) to realize a not-yet-completed part of the whole.

ll.

The standard by which Jeff judged his work was whether or not it incorporated "new stuff"—that is to say, technically interesting material that could increase his range of control over the machine. Between two of my visits, Jeff modified the "explosion" part of his space shuttle program. In the first version there was a rocket, a flash, and then nothing. In the revised version, there was the rocket, the flash, and a moment of disintegration before the pieces of the rocket flew off and there was nothing left. It was very dramatic and beautiful. I told him so. He found the compliment difficult to accept. The change was not fundamental. "It only made it look better. It's nothing new." To Jeff, aesthetics don't count for much—remember his shrug as he passed by Kevin's space scene. And yet, when Jeff improved his explosion, he received what was perhaps his first compliment for doing something aesthetically pleasing. Although he didn't accept it easily, indeed hardly at all, in the end he looked pleased. Jeff doesn't draw, or paint, or play an instrument. For him, the computer experience may spark an appreciation of other ways of knowing the world, because for the first time he can feel himself a participant in them. Programming, in this case hard programming, can bring him closer to "softer" pursuits in the arts.

In this situation Jeff's experience depended on my coming in "from the outside." But analogous situations emerge from the natural interaction of children with each other. Ralph is the star athlete of his school in suburban Boston; he is captain of two teams. Even at eleven he has a clearly developed sense of himself as a "macho man." He has little to say and nothing to do with Michael, a small, bespectacled boy in his class who is known as the "math whiz." Or rather, Michael is politely known as the math whiz. To Ralph, he is a "nerd": not good at sports, no "personality," a loser. What does interest Ralph are video games. And when computers—with their screens, their graphics, their movement, their sound effects—came into his school, Ralph was taken with the idea of creating his own video game, a football match using his own favorite plays. Ralph has lots of ideas for the game, but to get them on the computer he needs the help of an expert; he needs Michael. At Ralph's initiative, the two boys start to work together. Michael, for his part, has always admired Ralph, but he has never before worked on an intellectual problem with another person, "except maybe the teacher, but nobody else in this class really is into math the way I am." He is happy for the chance. Ralph takes him out on the playing field "to show him some moves" that need to be incorporated into the video game. Michael in turn shows Ralph his most secret programming tricks. The game becomes increasingly complicated. The two boys fantasize about someday "selling it to Atari and making a lot of money." They start to have lunch together, to talk. It turns out that Michael does have something to offer, and not just programming tips. Ralph tells me, "This guy is really into science fiction. I mean he knows everything about science fiction. All the *Star Treks*. And even better stuff. He is giving me all of the really good stuff to read." They don't become close friends—Ralph still has his world, and Michael doesn't fit into it; Michael still has his math, and Ralph isn't really interested—but they talk, they go to a science-fiction-movie marathon, they work on their game.

Stanley and Ben are in the same fifth-grade class and have been together at school since first grade. They are friends at a distance, but belong to two different worlds. Stanley is another math whiz and always has been. He is the child of academics and describes himself in terms of his technical interests. He has been fixing radios since he was five, is deeply interested in electronics and circuitry. He wants to be a patent lawyer when he grows up, and his reasons are "technology-driven." "You get to learn the latest stuff about machines and about computers, stuff you would need to know anyway." Ben is in the "other" culture, a dancer. When school is over he is off to dancing lessons or rehearsals. At eleven years old he is already a professional.

Stanley and Ben developed a collaboration that closely paralleled Ralph and Michael's, in this case to produce a program that would choreograph a dance of sprites on the screen. Each collaborator brought to the task something the other did not have. Ben brought his sense of form, of movement, and his already well-stocked repertoire of dance routines. But to translate these for the computer required Stanley and his repertoire of programming tricks.

It is striking, and it is sad, that elementary-school classrooms seem to be microcosms for the kind of "splitting" that divides the adult culture. Walk into these classes and you see the humanists and the scientists, the artists and the mathematicians, the physical types and the intellectual types. All too often, you see them having very little to do with one another.

What really matters is not what choreography rubbed off on Stanley or the mathematics that rubbed off on Ben, what sports knowledge rubbed off on Michael or the programming that

ill.

rubbed off on Ralph. What matters was that each child came, if only a little, to appreciate another aesthetic. Michael and Stanley took several steps beyond Jeff's "nothing new" reaction to Kevin's space shuttle. Ralph and Ben saw that mathematics could be personally relevant. When projected onto a future in which computers will be everyday objects in the lives of most children, these interactions could be a portent of new understandings in our culture.

Getting Stuck

The lives of all the children we have met so far seem to have been enhanced by their contact with computers. But for some children the computer seems to close as well as open doors. Jeff said the computer was "the most important thing in my life right now," but it was not the only thing. There are, however, children whose involvement with computers becomes consuming, almost exclusive. There is a narrowing of focus, a decreasing degree of participation in other activities.

Henry is such a child. He was having a difficult time before he met computers and learned to program. The computer did not create a problem where none existed, but he is an example of a kind of child for whom the computer may reinforce patterns of isolation and help lock a child into a world of getting lost in things at the expense of the development of relationships with other people.

The Austen School has two students who have taken on public identities as computer "whizzes." Jeff, whom we have already met, is one of them; Henry is the other. Henry spends a lot of time comparing himself to Jeff, whom he considers his rival. Henry is a small, unathletic child. He is awkward, tense, and self-absorbed. Whenever he came upon MIT visitors it was with an agenda. Without even saying hello, he would request some piece of technical information, something that "Jeff doesn't know." When we began to teach him about how to use x and y coordinates in his graphics programming, he commented, "Oh yeah, I saw Jeff do that. If I could do that I could do anything." His sense of being in competition went beyond his relationship with his primary rival. He defined himself and everyone he knew in terms of their place in a pecking order. He saw himself as the best in computers, and he was going to do everything to keep this place. He knew that the other students saw him as an expert, and he enjoyed the attention. He liked being in the limelight.

ill.

Henry knows that the limelight depends on his staying in a position of clear superiority by discovering programming techniques; in the social world of the school he has nothing else. He shores up his position by trying to control the dissemination of ideas. For example, he credits himself with having discovered the Logo instruction that changes the design of the blank-space character. This creates a dramatic patterned effect by repeating the chosen design in every empty space on the screen—including the spaces between words and at the ends of incomplete lines.* The discovery made him famous, but he has regrets. He reproached himself several times for having told other children about his discovery, saying, "It's really spreading around, but we are trying to hold it down." "We" refers to the small group of experts that Henry considers worthy of this knowledge. They can appreciate it. He divides the culture of Austen programmers into "us" and "them." The best discoveries are somehow violated if they are put into the hands of the "thems" who can't appreciate their technical ingenuity but who use them simply to achieve pleasing visual effects.

Henry's growing-up toys were machines—an old air conditioner, discarded radios, tape recorders, broken blenders—which he patiently disassembled and put back together. He never found other people to talk to about his discoveries and grew up pretty much alone. Alone, he made inventions. He claimed to be inventing things all the time, but when we visited he was particularly excited about two of them. One would give him access to free games of Asteroids; the second, he hoped, might make him a millionaire.

Henry told us about the Asteroids invention. He says he is such a good customer at the game arcade that the owner offered him a free game one day as he was making his rounds to open the machines and collect the coins. Henry says he watched the owner initiate a free game by pushing a lever inside the machine. The image of the lever stuck in his mind. One day while playing with some pacemaker magnets that a friend's cardiologist father had given him, he noticed that an attracted paper clip itself became magnetized. If magnets worked like this, couldn't he use a magnet on the "outside" to pull the "inside" Asteroids lever? The metal casing around the game wouldn't be an impediment. To his mind, it would only help him out.

---

* An apparently "empty" screen is actually filled with invisible "space" characters, the character invoked by pressing the space bar on the keyboard. So if this character is changed to have a visible form—and this is what Henry discovered how to do—the blank parts of the screen instantly fill up with a tiling effect caused by the repetition of the new form.

It is hard to tell if there really is an Asteroids invention. What is important is that Henry's fantasies are about making mechanical things that will allow him to "win" or triumph. The second invention was more obviously fanciful. This is one that he would like to patent because he thinks it will make him rich. He calls it a "gear rater." It is a Rube Goldberg device for making a superfast bicycle with many parts, many gears, many ropes and pulleys. It is a new kind of *dérailleur* which, it seems, would work by creating energy. You pedal the same amount, but you go faster.

These inventions and others were never very far from Henry's mind. Questions about what he thought or what he felt were answered with new anecdotes about building something or taking something apart. These technical descriptions are monologues, and, whatever the subject matter, Henry doesn't pause to check out the state of his listener. He speaks in a rapid staccato, punctuating his stories with machine sound effects: *brrr*, *crkkk*, *brrrt*. His hand gestures are sharp and geometric. He uses them to indicate quantity, position.

Henry dreams of becoming an "electronics person." This fantasy includes "building a person out of lights," a person made of wires and circuits. "I would work with the electronics and wires and control things. I have a kit of little circuits now and I can control them." It often seems that Henry would rather control or ignore people than deal with them directly, just as he would rather control or ignore his feelings than deal with them directly. When the conversation turns to things that make him anxious, he retreats into stories about his machines, his inventions. Machine sounds (like his *brrrs* and *crkkks*) substitute for talking about how he feels.*

---

* Henry's Rorschach showed a higher than usual proportion of machine images, often embedded in a story that made it clear that he controlled them. Mechanical forms were imposed on the blots even where their shape and size did not suggest them. This imposition of "inappropriate" forms is some measure of Henry's need to see things in terms of controllable objects. In the Rorschach, as in conversation, a tense moment would lead to a retreat into stories about his machines, his inventions, the gear rater, the Asteroids machine, ideas for space travel machines. Again, as in conversation, machine sounds substituted for talking about how the cards made him feel. Like the Rorschach, Henry's performance on the locus of control test also suggests a very strong need to feel that events will not happen to him but that he will make them occur.

Henry was awkward with us, on the playground, and in conversation with other children. He was rude, or embarrassed, or withdrawn. Not surprisingly, it was at the computer that he relaxed. Here he was in complete control. He typed rapidly, pronounced every letter, number, and space of the Logo code he composed. His programs were very long, very involved, and written in a way only he could understand. When people try to make their programs understandable, they divide them into "subprocedures" (smaller programs that serve the larger program) and name them in ways that indicate their function. Henry's style was to bypass this kind of technique in order to create a labyrinth of code. Making them esoteric made them private. Making them private made him sole owner and helped him to keep his advantage over the other children. Making them complicated, often unnecessarily complicated, also made them seem "harder," not just to the other children but, to a certain degree, to himself. He enjoyed whatever increased his sense of dealing with terribly complex and arcane things. Whenever he could, he increased the "automaticity" of the computer, he tried to make it even more "alive." For example, he wrote a special-purpose program to give him quick access to the editor. He enjoyed adding the extra level of complexity to the system. He seemed to want to confer as much as possible a sense of autonomous existence on the computer. This gave him an empowering sense of control.

For the hard master the keynotes of programming are abstraction, imposition of will, and clarity. For the soft they are negotiation and identification with the object. Henry has a hybrid style. In many ways he is like a hard master. He revels in technical detail, he takes pleasure in imposing his will over the machine. But, for him, the keynote of programming is not clarity but magic. Jeff wants his programs to be clear so that he can share them and be famous. Henry wants his programs to be impressive but mysterious. The goal is the creation of a private world. He expresses this clearly in his labyrinthine code. He expresses it clearly, if less obviously, in his relationship with powerful programming ideas. Both Jeff and Henry asked us to explain the use of Cartesian coordinates. Jeff was looking for an understanding and illumination. Henry was looking for a magical spell. What most pleases Jeff is the effect that unfolds following a process whose logic he has set up and worked to make transparent. The discovery for which

Henry is proudest, his transformation of the blank character, produces an instantaneous and dramatic effect. Its source of power is buried deep and hidden within the machine. When he gives his command, he is releasing a force, invoking his personal, magical power.

When hard masters meet the idea of "structured programming," using nested subprocedures to give programs a transparent, hierarchical structure, they are excited. They have found a tool that meets their ends. The softs are more resistant. They use structured programming as a technique, but they don't particularly like it. It takes away from the immediacy of the relationship. Like the soft master, Henry's pleasure in programming is tied to that sense of immediacy. He has none of the hard master's distanced stance toward his creation. Like the soft master, he is right in there with the sprites. Indeed, Henry's way of identifying with the computer goes far beyond anything that we have seen soft masters do. Beyond identifying with the sprites, Henry actually identifies with the computer. People and powerful emotions are threats. Seeing oneself and others as controllable machines is a way to be safe. Recall Henry's fantasy of building a person out of lights, a person he could control.

Henry didn't like talking about feelings and claimed not to remember any dreams about the computer. But one morning, after a long interview, he volunteered a dream in which he had to match wits with an evil rival, equally skilled in the mysteries of the machine. He came to the school one night, and all the windows were broken and all the computers except one were gone. He gave the instruction "TELL BACKGROUND SETCOLOR :BLACK," an instruction that dramatically leaves colored shapes luminescent in black space, and the message "YOU ARE GOING TO DIE" appeared on the screen. Then a riddle appeared that forced him to "match knowledge about computers" with the man who stole them. Henry won, got the computers back, and got to take one home. "Then I became a hero at the school." The dream was about mastery, mystery, danger, and winning the admiration of others for solving a puzzle on which life and death depend.

It is interesting to compare Henry's dream with one related by Kevin, the artistic soft master. Kevin's dream involved the same instruction to turn the background color of the display screen to black, but, in contrast to Henry's dream, there was no danger, no threat, no matching of wits. The dream was simply about the computer wanting its turn to give instructions, consistent with Kevin's "conversational" style of negotiating with the machine. The computer appeared to Kevin with a broad smile on its face. It spoke to him: "TELL BACKGROUND SETCOLOR :BLACK." It was not clear whose background was changed by the command.

In general, the presence of computers does not lead children to think of people as machines. But Henry shows us the psychological context in which this fear is most real.

Just as for Jeff and Kevin, Henry's style of relating to the computer is illuminated by a comparison with a clinical category, in this case, the idea of a schizoid style. This style has its roots in infancy and early childhood. It has its roots in a crisis not of sexuality but of what psychoanalyst Erik Erikson called basic trust: the fundamental confidence that there is a constant and a caring other, that "when I cry I will be fed." In the absence of this trust, the process of differentiation of the self from the mother is fraught with conflict. The child grows up with an impaired sense of self. There is a feeling of emptiness and a desperate need for other people to give a sense of being there.

The lack of trust that causes the problem blocks its solution. Not developing and internalizing a good and trusted image of the mother creates later difficulties in relating to anybody in an intimate way. The early experience of love rejected is transformed into rage against the other who frustrates and terror of the other to whom one is so vulnerable. There is fear of relationship, fear of being rejected, and, since one feels like nothing, fear of being swallowed up.

This is the description of a paradox: a terror of intimacy and a terror of being alone. When people are caught in this position they use a range of strategies. In their fear of intimacy, they flee toward not feeling—being depersonalized, frozen, numb, split off, lost in abstraction, lost in battles of ideas and great principles. In their fear of being alone, they desperately seek validation in the eyes of others. They want to be admired. But since they do not feel themselves to be true selves, the only way to gain admiration is by manipulating appearances, by magic. This is Henry's paradox and these are his strategies.

A culture expresses its essential conflicts in its dominant psychopathologies.[21] Hysteria, its origins in sexual repression, was the neurosis of Freud's time. A repressed thought finds its expression in a physical symptom: a paralyzed limb speaks for an unacceptable wish. In the later twentieth century, cases of hysteria have virtually disappeared. Indeed, clinicians report that their patients rarely suffer from a clear symptom of any kind. What they are suffering from is that sense of feeling empty, of feeling nothing, of not being able to relate. Schizoid process has taken the place of the classical neuroses.

Machines come into this picture in two ways. One can come to see oneself as a machine—this provides protection from feeling, invulnerability to the threat of being swallowed up. And one can turn to the world of machines for relationship. With the computer, both possibilities are enhanced. There is a "mind machine" and therefore more sophisticated machine models with which one can identify. And the computer, reactive and interactive, offers companionship without the threat of human intimacy.

Henry was involved in a private world of machines before Austen ever got its first computer. What difference did the computer make for Henry, and what difference will it make for him as he grows up? The answers to such questions are complex. When Henry was absorbed in his world of broken air conditioners and largely imaginary inventions, he was completely alone. He had no one to talk to about them; there was no one to listen. The machines reinforced his isolation, his living in a private world. But as computers and programming began to be the center of his inner life he had something to share, to engage others with. He became part of a community of other young people who are captured by the computer. So in a certain sense the computer brought him out into the world of people.

But there is another way of looking at the role that the computer is playing in Henry's development. Henry was lonely in the world of old machines and imaginary inventions. He received little reward or encouragement. Social pressures were pushing him toward other things. He was resistant, to be sure—he needed his machines because they kept him safe from social involvements that felt threatening. But adolescence is just around the corner for him, and with its changes Henry may be able to move beyond his safe machine world to experiment with the less predictable and controllable world of people. But at the same time some of the pressure to do so has been removed. His teachers are pleased with him, his parents are pleased with him, he can turn his computer skills into a lifetime career. There exists a waiting culture of master programmers that he can join—a culture that may reinforce and reward his exclusive involvement with the machine. The interactivity of the computer may make him feel less alone, even as he spends more and more of his time programming alone. There is a chance that the computer will keep him lost in the world of things.

Most children of Henry's age are involved with mastery, with testing their competency. But here, as at every age, most children strike a balance—the need to win is tempered with the desire to do things with people where the results are never as clear. The computer is a powerful medium for playing out the intense desire to win that is at the center of Henry's preoccupation. The danger is that its challenge will be so seductive that he will play and replay winning to the exclusion of more complex satisfactions beyond it.

for mastery of skills & Any concrete materials

Mr. BROWN. Thank you very much, Dr. Turkle.
We will go ahead with Dr. Bell.

STATEMENT OF DR. FREDERICK H. BELL, PROFESSOR, MATHEMATICS AND COMPUTER EDUCATION, UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA

Dr. BELL. Mr. Chairman, I appreciate being asked to come here to comment on the specific needs of teachers and how these two bills might or might not meet those needs.

With your permission, I will deviate from my prepared paper and discuss some related issues.

Mr. BROWN. Without objection, the full text of your statement will be included, and you may deviate as much as you wish. And Dr. Turkle, the additional material that you wanted will be made a part of the record after your statement.

Dr. BELL. I was asked specifically to comment with respect to my perspective over about 20 years in working with local school districts and teacher education programs. And also some of the lessons that we learned in the 1960's and 1970's with respect to using computers in education, many of which I think have been forgotten with the advent of microcomputers in the schools.

I think that in both of these bills, particularly in the bill dealing with computer literacy, that teacher education has been neglected. On a purely quantitative basis, there are about two small paragraphs dealing with teacher education.

On a more qualitative basis, with respect to what I know is a budget estimate, $120 million was estimated in the budget with respect to teacher education, and in the descriptive part, all of that money was allocated to stipends.

Now, I realize that that was not a hard and fast budget, and it does say that the needed funds will be allocated. However, there is no indication as to how much these funds will be.

I think that in one sense, the computer literacy bill, especially with respect to the hardware—in fact, primarily with respect to the hardware—may be too much too soon. I am not sure that school districts will be able to absorb and properly use and properly educate their teachers with this kind of influx of hardware.

Depending upon the most current data, I would estimate there are probably about 500,000 computers in the schools. I believe the 350,000 figure was roughly for last fall. So by next fall, I will assume 500,000.

So this bill will nearly triple the number of computers in the schools. Also, this may be too soon because the computer technology is evolving very rapidly and in the next 3 years the schools may end up with a great deal of hardware that is quite outmoded with respect to new technology.

With respect to the bill concerning the National Software Act, I think that bill is a little bit too late. I think that 4 or 5 years ago there may have been a need for that, even 2 or 3 years ago. But I think that at this point, the publishers are realizing what the market is and what is needed and I think that this will probably be done through private enterprise and cooperation through school districts.

In fact, the publishing companies right now are on the verge of integrating computer-based software with textbook series, and teachers primarily use their textbook as the main source of material in the curriculum.

If that textbook has computer programs with it, they will also use the computer programs as well. I would like to address also not only the needs of teachers, which I have done in my prepared statement, but the needs of the children and adolescents who will be using this hardware.

Based upon past history, I asked myself the question, what do we do well at teaching? And we do fairly well at teaching facts, skills and concepts to students.

We can do even better with appropriate drill and practice software. But I don't think that this is where the computer has its real impact or its real potential in the schools.

What don't we do very well in our school systems? I think the things that we don't do very well in teaching are those things at the higher cognitive levels: critical thinking, analysis, synthesis, evaluation, decisionmaking, creativity, things of this type.

Some of the software available does promote analysis and synthesis, but I think we need to look more so at the program languages with respect to creativity and decisionmaking in the schools with children and adolescents.

As has been mentioned before, LOGO is a very excellent language. It is becoming—it hasn't become yet, but it is becoming the language of elementary schools.

LOGO is not a language that one learns. LOGO is an environment in which one explores. One explores art, motion, creativity, movement, color. It is a mind stimulator.

I believe the term "wheels of the mind" was used before. It is certainly a wheel for the mind.

And I think that at this point, with the somewhat unknown state of software for the very near future, LOGO is a very good way to stimulate some of the higher level cognitive processes in schoolchildren.

In high schools most of the teachers who are using computers teach programming languages. Nearly all of the teachers who teach programming languages teach BASIC, because BASIC is a language on the machine.

BASIC has been criticized because it is not a structured language. I think that is what is good about BASIC. It is not a structured language, and it requires one to structure, organize, synthesize, evaluate and make changes and do some high level critical thinking.

So I think in practical terms, LOGO is being done and BASIC is being done, and there are very good reasons to continue to do this as well, in support of other types of courseware that are used for teaching basic skills.

With respect to teacher education, I think teacher education right now is at one of its lower ebbs in our recent history. About 1975, teacher education started to deteriorate, at least quantitatively, because the rumor was that there is going to be an extreme excess of teachers, so don't go into teaching.

Teacher colleges who were training 30 to 50 teachers per year cut down to three or four per year, and they emphasized their liberal arts programs.

In many areas there was a surplus of teachers. Unfortunately, there was not a surplus of teachers in math and science, and the fact that the word was out that teachers can no longer find jobs is probably the key element in the shortage of math and science teachers at this point today.

One of the ways that this shortage of math and science teachers is being solved is by second field certification of teachers who are trained in other areas, anywhere from music to social studies to physical education.

I don't think this is the best way to train math and science teachers, but nevertheless, it appears to be the way that it is being done.

Also, with respect to the proposed National Science Foundation Institutes, my exerience has been that one doesn't necessarily attract the best quality teachers by paying fairly large stipends. I think one of the better ways to train teachers is through cooperative efforts with school districts, a particular school district who may send 20 or 25 teachers to a training session, which would be planned in conjunction with a university teacher training organization or some other organization.

So I think that in summary, that with respect to the Computer Literacy Act of 1984, I think it certainly does meet our hardware needs, and I think it exceeds them at this point.

I think it does meet the planning and informational needs of local school districts. I think it does go one step in the right direction toward stimulating quality of software development through better educated teachers and funding for evaluation and dissemination centers.

I think it certainly does not adequately meet the short-term nor the long-term teacher education needs with respect to using computers in education. And as I said before, I think the National Education Software Act may have some potential for stimulating some high level creative software, but I doubt if it will be highly successful and I think it may be about 2 years past the need for it.

Thank you.

[The prepared statement and biographical sketch of Dr. Bell follow:]

Testimony on bills H. R. 3750 and H. R. 4628
Prepared for the U. S. House of Representatives
Subcommittee on Science, Research and Technology

by

Frederick H. Bell

Professor and Coordinator of Learning Resources Center
School of Education
University of Pittsburgh

June 5, 1984

EDUCATION NEEDS OF CURRENT AND FUTURE TEACHERS AND THE CAPABILITY OF THIS LEGISLATION TO MEET THESE NEEDS

TOPIC 1: TEACHER TRAINING NEEDS

One of the critical needs for effective uses of computer technology in schools is high quality teacher education. Current and future school teachers need help in becoming computer literate. They need to learn how to use various types of computer-based educational software effectively and efficiently. Teachers should be aware of the technological developments that made computers possible. They should know about the history of computing and data management hardware and software. Sound knowledge of computer uses in society and future directions for computers is also important.

Teachers need to become familiar with computer jargon. They should learn how to operate computers and how to use courseware effectively. The ability to evaluate and select appropriate hardware and software should be part of each teacher's education. As computers appear in classrooms, teachers will need to integrate computer software with other classroom resources. In fact, large-scale uses of computers in schools necessitates course and curriculum reorganization. New classroom management procedures are needed for computer-oriented education. Teachers will be learning more efficient ways to handle clerical work and to schedule their time. School administrators will need to develop new management skills in order to assist teachers in organizing effective computer-oriented classrooms.

Better software is required to aid teachers in teaching basic skills and to help students learn these skills. While good courseware can assist students in mastering basic skills, the real potential of computers in education is found at the higher cognitive levels. However, in education there is still a tendency to use computers to do the same tasks in much the same way as was done before computers came to school. Currently there are some good courseware packages for skill learning and practice and a small selection of effective simulation packages is available. But not much of the current courseware addresses learning the types of critical thinking involved in applying skills and knowledge to new tasks. Analysis and synthesis tend to be neglected. Evaluating situations and making decisions are dealt with insufficiently.

Students need to learn in modes that permit and even require them to think analytically. They need to practice synthesizing conceptual models and evaluating their models in a professional manner. Practice at solving interesting and significant problems can be carried out in computer-enriched learning environments. Decision making, learning how to learn and creating knowledge can be nurtured with good interactive software. Creativity, which is difficult to define and even more difficult to teach, can be developed in computer-enhanced classrooms.

During the 1960s and 1970s, it was demonstrated that computers can be used to teach facts and skills. But what about the higher-level cognitive activities--those thinking processes that we have not been able to teach very successfully in schools? Here is where the potential for revolutionizing education by using computers in schools is found.

Among the many ways that computers are used in schools, there are at least two ways to promote their use for high-level learning. One way is to develop and promote software that gives practice in analysis, synthesis, evaluation, problem solving, decision making, and creativity. There is some computer software that does this now. But there is not nearly enough of it available for schools. Another way to involve students in high-level mental activities is through learning a programming language and writing programs to do useful tasks. When individual initiative is encouraged, learning a programming language immerses one in analysis, synthesis, evaluation, problem solving, and creative activities.

The Logo language epitomizes the best currently available software for learning in school. Logo is a creative medium which is learned somewhat in the way that geometry was created. One does Logo by solving self-determined problems that may involve exploring geometry, art, colors, motion, and Logo itself. Logo is an excellent language for involving teachers in classroom uses of computers and helping them develop computer literacy. They become fascinated by what can be done with Logo and the individucal initiative that it permits in problem-solving learning environments.

The BASIC programming language also is a good medium for high-level thinking in the context of computer literacy. Although criticized for its lack of structure, this lack of structure makes BASIC a good language for intellectual explorations. This lack of structure fosters creativity and encourages students to develop their own models for structuring their programs for better efficiency. There are two reasons for using BASIC as a medium for promoting problem-solving heuristics and creativity rather than using another language: BASIC is included with nearly all microcomputers, and secondary school teachers have been using it for years as their primary computer literacy activity. As reported in Vol. 15 of REPORT ON EDUCATION RESEARCH, it was found in a study conducted at Johns Hopkins that 76 percent of secondary teachers using computers used them to teach programming. BASIC was used by 98 percent of schools that provide at least 30 hours of programming instruction.

While waiting for better high-level subject-specific courseware, Logo and BASIC can and are being used to promote computer literacy and expand students' intellectual horizons.

TOPIC 2: CAPABILITY OF THIS LEGISLATION TO MEET THE NEEDS OF TEACHER EDUCATION

There appears to be an oversight or clerical error with respect to funding for teacher training in the COMPUTER LITERACY ACT. On page 14 of this ACT, the total estimated authorization for teacher training is 120 million dollars. However, 121 million dollars is authorized for teacher stipends in Section 202 on page 4 and in the text below the table on page 14. Consequently there is no indication of funding for grants and contracts to provide for the National Science Foundation training institutes.

Excluding funding for teachers' stipends, the other costs for grants and contracts to train teachers could range from 32 million dollars to 132 million dollars, based upon cost-per-hour, per-trainee estimates. Regarding teacher stipends, my experience indicates that they may not be necessary to fill institutes (especially computer-literacy institutes) with well-motivated teachers. In many instances, an effective way to deliver hands-on computer education is in groups of approximately 20 teachers from a single school district. The district can plan the institute with the training organization. Teacher instruction may be delivered in the school district using its hardware.

A need for more than two billion dollars to purchase 1.3 million computers for schools is identified in the bill. No funding is specified for hardware support of the teacher-training organizations that will deliver the teacher training in the NSF institutes. I doubt that enough organizations will have adequate microcomputer resources to deliver this magnitude of high-quality computer-literacy instruction. Equal access and adequate distribution guidelines for computer hardware may need to be applied in the COMPUTER LITERACY ACT to teacher-education organizations so that they can catch up with the schools. According to Charles Blaschke as printed in the January 18, 1984 issue of EDUCATION COMPUTER NEWS: "States realize that it's going to take a while for universities and teacher colleges to catch up to the demands for computer literacy."

As the COMPUTER LITERACY ACT stands, a very small percentage, maybe 1 percent, of the more than 2 billion dollars, will be used in any way to support teacher education institutions. These institutions have the final long-term responsibility for inservice and preservice education of teachers on uses of computers in schools.

The COMPUTER LITERACY ACT will triple the number of computers in schools, which will put the universities and teacher colleges even farther behind the schools.

Teacher education programs in colleges and universities also need computer hardware to carry out their function with

BEST COPY

respect to training teachers to make effective use of computers in schools.

In summary, it is my opinion that the COMPUTER LITERACY ACT of 1984:

1. does meet, and may even exceed, the need for adequate distribution and equal access to technology for schools,

2. does meet the planning and informational needs of local school districts,

3. does aid in meeting a need for stimulating quality software development through better educated teachers and funding for evaluation and dissemination centers,.

4. does NOT adequately meet the short-term need for teacher education on computer literacy, and does NOT address the long-range need for preparing computer literate teachers for elementary and secondary education.

The NATIONAL EDUCATION SOFTWARE ACT of 1984 may stimulate development of high-quality software for elementary and secondary education.

Respectfully submitted by Frederick H. Bell
Professor, University of Pittsburgh.

FREDERICK H. BELL
Resume Summary

Education:

B. S. in Mathematics Education from Clarion State University
M. S. in Mathematics from Kent State University
Ph. D. In Mathematics and Computer Education from Cornell University

Teaching Experience:

Chairman, Dept. of Mathematics, Canton Technical Institute for 5 years
Associate Professor of Mathematics, Clarion State University for 1 year
Professor of Mathematics and Computer Education, University of Pittsburgh since 1971

Articles Published:

More than 30 articles on mathematics and computer education in various magazines and journals

Papers Presented:

appromimately 65 papers presented at National and State conferences

Books Published:

TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS, 1978 BY Wm. C. Brown Co.
TEACHING ELEMENTARY SCHOOL MATHEMATICS, 1980 by Wm. C. Brown Co.
SOLVING ALGEBRA MYSTERIES, 1982 by Hayes School Publishing Co.
SOLVING GEOMETRY MYSTERIES, 1983 by Hayes School Publishing Co.
COMPUTER LITERACY WITH BASIC PROGRAMMING, 1983 by Hayes School Publishing Co.
TRS-80 PROGRAMMING FOR LEARNING AND TEACHING, 1984 by Reston Publishing Co.
APPLE PROGRAMMING FOR LEARNING AND TEACHING, 1984 by Reston Publishing Co.
IBM PROGRAMMING FOR LEARNING AND TEACHING, to be published by Reston Publishing Co., Winter 1985
EXPLORING STATISTICS AND PROBABILITY, to be published by Hayes School Publishing Co. in 1984

Curriculum Modules Published:

50 curriculum modules for teaching mathematics in grades 2 through 12, published by NEI Croft Co.
65 Metric activity cards published by NEI Croft

Consulting:

Assisted more than 30 School Districts in improving their mathematics and computer education programs
Served on the team that developed the Pennsylvania Computer Literacy Program

Mr. **Brown**. Thank you.

Now, Dr. Rutherford.

STATEMENT OF DR. F. JAMES RUTHERFORD, CHIEF EDUCATION OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. **Rutherford**. Good to be here and see you even at 3 o'clock on a bright sunny afternoon. Actually, it was worthwhile.

I discovered today for the first time what advantage there is in being a Government official, which I was at one time, you may recall. It is that you get to go first. And did you notice who came in, the first two people that testified, and then got to leave.

So there is some advantage in being in Government. Not that I would want to be there.

Mr. **Brown**. You are much better off, Dr. Rutherford.

Dr. **Rutherford**. Right. Especially under prevailing circumstances.

In any event, I will let my written statement speak for itself as best it can, and make a couple of points so that we can all be on our way.

First, the problem is educational. The problem is not computers. Computers may or may not turn out to be useful in helping us to solve our educational problems.

They can also contribute to our problems if we treat them poorly, or believe that they are magic, or fail to take advantage of the experience we have had over the years in how to do things in the schools.

So let me suggest three things that I think that these bills and others ought to be about.

The first is take into consideration, time to modernize the entire educational establishment. Talk about computers, or to talk about a new disc or this or that is to miss the point.

We are new times. The world is changing. The system is not adequate to the kinds of children, kinds of people we are going to need, we need right now and in the next century.

That is true in all countries. So we have to get to work and modernize the system—take it out of the 19th century, get it into the 21st.

Now, if that is what we want to do, then little questions about how many computers there may or may not be in a school is entirely beside the point. Let me suggest a couple of things that need doing if one subscribes to this.

In the first place, we ought to leap frog, not limp, into the future, into the technological future. That means looking ahead of the game and saying how can we get way out in front for a change.

You know what happens in education. People elsewhere invent something—radio, say. And 5, 10, 20 years later, the educators come along and say, gee, you know, I bet we can use that in the schools. You know to this day the most powerful technology of all, radio, is not being imaginatively used in the schools of this country.

And we did it with television, which we took to be radio with pictures, and so forth. So we ought to leap.

And to do that I would suggest that we ought to move not only the computers, but to computerized videodiscs, that is, to the technologies that bring the visual, the video technologies developed over the last 50 years, put them together with these new electronic computer technologies, to get out in front.

This would allow us, among other things, to create technologies that would serve in the first instance the educational and learning needs of people, and not always be trying to adapt something to those needs.

So that we could define the standard, we could define the makeup. I don't believe any of those computers in the schools today are appropriately designed mechanically, conceptually or electronically for the work to be done there.

So let's leap frog.

Second, let's start the business of designing a complete telecommunications system connecting all of the schools, colleges, and libraries together in one vast educational network.

It is entirely possible to do that, with the technology that exists today. We simply don't ask the question about computers. Say, given satellites, and cable, and receivers, and video copiers, and video players and computers and videodiscs, given all of that technology, who would put it together to see to it that our young people and their teachers and their parents can have access to the marvellous kinds of creative materials, visual and otherwise, that we are able to produce and are producing.

Well, that suggestion among other things, if we try to do that, look at all the communications and information technology, we won't be talking so much about, for example, personal computers.

Well, these exist, and they ought to be taken into the mix and looked at, to do certain kinds of things. But my guess is many of the things we want to do are not doable on those instruments.

So why are we talking about computers as though that were it. There are lots of possibilities.

I think if we were serious about this, we would accelerate our investment in R&D. Today the National Science Foundation claimed that they were doing just fine with their investment in education and in things related to computers.

Well, they are doing some of the right things and we have for 20 years. They are so far below the level where they ought to be, it is not close. They need to multiply by several times the intensity of the effort they are making, especially on R&D.

And that R&D ought to be basic, it ought to be applied, it ought to do with hardware and software, it ought to be how you organize schooling in institutions to incorporate technologies and people to accomplish what we need to accomplish.

This would get us into the standardization problem, which is precisely where we ought to be. It is silly to believe that we have to go on forever with every machine having its own software. Imagine if we did that in print technology or television.

But if we get out in front, we can begin to determine some of the standards and the equipment used in the schools. That is the first point. It is time to modernize education.

The second is it is time to plan for reform. Plan. Don't believe and don't write into your bills the belief that lots of things will happen out in thousands and hundreds of thousands of little places as if by magic—it will all add up to a national policy and a national direction.

Now, education is a national problem. It wasn't when the Constitution was written.

But that was some years back. The fact is now it is of national concern, the quality of the education. And every child, it doesn't matter whether in California, there is a company that will donate some computers or not.

It has to do with all of our children and all of our people. But that has to be planned for. And it has to be planned for because lots of things, in fact, are happening.

And it is only if we have planning going on between the feds and the State people, between the State and the schools, as a precondition for investment in technological materials.

Don't put the materials in and then plan. You start making up plans. Imagine that we wanted to get to the Moon.

We look around and say why don't we take a DC-3 and strap a rocket on it. We had rockets and DC-3s. We would never have gotten to the Moon.

So you have to go the other way around. There has to be a lot of local planning that mostly is not happening, and all you have to do is walk into a few schools and see where the computers are, how they are used and the degree to which teachers are, in fact, not trained or have not psychologically taken these things into their own culture.

And that is going to take awhile. But it is going to take planning.

I could say more about that. But let me leave this with one example. There is a lot of talk about teacher training.

I just mentioned that the system is not going to work unless teachers can cope with it, learn about it, build it into the curriculum, integrate it with what we are trying to achieve—not hold it up as a shrine, an object of adoration, but rather something to help do the job.

The teachers have to know things they don't know. They have to know how to teach their subject using these kinds of things.

But why haven't we been talking about using these very same technologies to finally come to terms with the teacher training problem. There are 2.5 million teachers in America. Do any arithmetic you want, and decide what it would cost you in any sensible program of teacher training and you are talking billions annually.

Now, I say for a small fraction of that we could put the audiovisual electronic computer technologies to work to provide daily, weekly, year in and year out, instruction to teachers, not on everything, but on much.

So you see the problem is not only to think of the children, the students, as what we focus on, but how to use, build and plan for a system that will provide life long continuing education to the teaching faculties of our Nation.

My final point is that not only is the time to modernize and plan for reform and get it to happen, but it is time to invest in reform. We have enough of what to begin to do to start doing it.

But none of the numbers being talked about, in or out of Congress, are very close to what it is going to take to turn a 19th century system into a 20th or 21st century system that has vastly more responsibilities than the systems of previous centuries, and where the stakes are much higher.

We must invest, as I have already indicated, in far more R&D than we have been doing. Basic things having to do with knowledge, research on the structural mode, instructions on systems and how they work.

We are doing some of this—marvelous research like Dr. Turkle and others. But it has to be multiplied many times. And we have to get the best researchers in the country.

We need a nationwide education telecommunications system. I would create a corporation, not to create software—that is the easy end, the trivial end almost—I would create it to put the satellites up, to maintain them, to get a receiver in every school and college and library, put copiers there.

In other words, do what we did for the weather system, I would do for the schools. Or to take another analogy, what Carnegie did for the towns by putting libraries there, we would do for the schools.

Or what the highway system did for America, we would do for the schools. And then that would open up and make it possible for all kinds of materials from all sorts of sources to get to the schools.

Right now we create things that get shown once, they disappear. Finally, as a footnote to that, not quite such an important point, but it may be a psychological if not philosophical—let's not believe we can depend upon the charitable contributions of industry to deal with this problem.

Not only isn't it their business to be giving gifts to the schools of America—nice, I don't question their motives, but it doesn't much deal with the problem, which says education is a public responsibility, we ought to decide what we want to do, decide how to get it done, and then go about doing it.

Furthermore, as well meant as it might be, there is also the problem that sometimes it permutes the system because, you see, it interferes with the very kind of planning I have been talking about, because it puts lots of things in the schools that then somehow or other have to be dealt with after the fact.

So these, then, Mr. Chairman, are my points. Let's get on with the job of modernizing the schools, planning for reform and investing in it, because the stakes are high, the Nation needs it, and we are long overdue.

Thank you.

[The prepared statement and biographical sketch of Dr. Rutherford follow:]

Testimony on

H.R. 3750 and H.R. 4628

by

F. James Rutherford
American Association for the Advancement of Science

before the

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

of the

COMMITTEE ON SCIENCE AND TECHNOLOGY

on

June 5, 1984

Thank you, Mr. Chairman, for inviting me to comment on these two very important bills. There is no question but that they have zeroed in on what are key problems and opportunities in American education. Because other commentators coming before you are better qualified than I am to deal with the technical content of the bills, I have confined my remarks to a few recommendations for your consideration.

1. ANY FEDERAL INVESTMENT IN THE ACQUISITION BY SCHOOLS OF COMPUTERS OR OTHER INFORMATION TECHNOLOGIES SHOULD BE CONTINGENT ON ADVANCE PLANNING.

There is no reason to believe that simply providing the schools with microcomputers will do much to improve education. Indeed, the thrust of our experience in the United States gives us every reason to believe that doing so will mostly be a waste. Time and time again we have flooded the schools with new instructional technologies -- film projectors, television, language labs, scientific equipment, and more -- always with high expectations, always to be disappointed in the end. There is no easy technological fix to be had, no magical machines to solve our educational problems quickly, painlessly, cheaply.

Our failures in the past have had to do less with overestimating the power of new technologies than with underestimating the effort necessary to exploit that power effectively in the schools. I am pleased, therefore, to see that H.R. 3750 and H.R. 4628, taken together, acknowledge this by proposing a comprehensive approach to the utilization of computers for educational purposes: R & D, information sharing, materials development, teacher training, and other necessary elements of a systematic effort are included. This is all the more reason, I believe, to strengthen the bills to insure that thoughtful planning takes place at every level -- federal, state and local -- before providing the schools with more computers.

o The National Science Foundation, the National Institute of Education, the U.S. Department of Education, and the Department of Defense all have made important contributions to the use of computers in education, and presumably intend to continue doing so. Many of the individual States have also initiated programs to serve the same ends. In the interest of making the best use of resources and of seeing that no critical functions are overlooked, joint planning for coordination and collaboration is essential. This planning should be in response to a Congressional mandate that spells out goals rather than details of operation. Perhaps a Council for the Use of Computers in Education could be created to oversee the planning and to advise Congress and the appropriate federal and state agencies on the distribution of responsibilities and resources.

o Planning at this level is important for more than reasons of economy and coordination. It may be the only chance we have to focus our resources and attention on efforts to realize the most powerful and unique features of the computer as an educational tool. As the survey of Henry Jay Becker and his colleagues at the Johns Hopkins University Center for Social Organization of the Schools has shown, the schools are mostly using computers in ways that promote rote-learning rather than the development of higher-level intellectual skills. (The significance of this natural drift toward the easy and commercially attractive uses of computers in the classrooms, to the detriment of more sophisticated uses, has been set out by Professor A. B. Arons in this week's issue of SCIENCE, which, with your permission, Mr. Chairman, I would like to submit for the record.) This situation can only be turned around, in my judgment, by enlightened Federal and State programs based on thoughtful planning and future-oriented policy guidance in the use of resources.

o The same can be said for insuring that the already educationally advantaged are not once again favored over the disadvantaged in the distribution of educational resources. A simple formula will not do; it will take careful planning followed by unambiguous policies and continuous monitoring if girls, ethnic minorities, the poor, and the physically handicapped are to be fairly served.

o Local preplanning may be even more important. Computers will surely experience the fate of other technologies of high promise -- ending up unused in closets, or used by only a few teachers, and even then in mostly routine ways -- unless teachers and administrators participate in determining how, when, where, and for what purposes they will be used. Such planning needs to set priorities, to agree on a process for the introduction of computers over time, and, in concert with State education officials, to decide on a scheme for training all of the teachers, administrators and support staff in the local district. A fully worked out plan should be a condition for State support, just as a comprehensive State plan ought to be a prerequisite for Federal assistance.

o Computers and other technologies can, if wisely used, enable teachers to do better what they are already doing. They also may make it possible to restructure the process of schooling considerably, and to enhance the role of teachers. Thus, part of the planning at every level should focus on ways and means to use the new technologies to achieve fundamental reforms.

2. AN EFFORT SHOULD BE MADE TO EFFECT A QUANTUM LEAP IN THE MODERNIZATION OF EDUCATION BY INVESTING GOVERNMENT RESOURCES PREFERENTIALLY IN R & D ON LEARNING SYSTEMS THAT COMBINE VIDEO AND COMPUTER TECHNOLOGIES.

Each information technology has its strengths and its limitations. What is so striking about computers, what makes them so attractive as learning instruments, is their interactive nature. Unlike audio and video technologies, computers do not permit intellectual passivity--to use them you must engage them. It is through that engagement that the power of the computer as an analytical tool is gained. It is just that capability, indeed, that we need to put to work, and not settle for using computers as drill sergeants or electronic page-turners.

But computers are not good at displaying things and events in the real world, or at presenting rich human discourse, insights, idiosyncrasies. On the other hand, an amazing array of audio and video technologies (telephone, radio, LPs, audio tape decks, transparencies for overhead projection, slides, filmstrips, super 8 film loops, 16mm movies, slow-motion and time-lapse photography, photomicroscopy, television, video cassettes, etc.) can do just that. If the schools have not exploited these technologies fully, and I believe it is agreed that they have not, it is for both pedagogical and logistical reasons. The pedagogical weakness of audiovisual materials is that they do not require, by their nature, the active intellectual participation of the learner; and then the selection, operation, maintenance, scheduling, and management of such a diverse array of materials and devices turn out to be very difficult, as a practical matter, in most schools.

Now, as luck would have it, these two separate technologies are producing a hybrid that offers great promise for the future of education: the interactive videodisk. The laser videodisk is able to capture an enormous amount of visual and audio information on a single, nearly indestructible record, and the player allows rapid random access to that information. The videodisk by itself can conveniently replace nearly all of the audiovisual devices and materials now (fitfully) used in the schools. But connected to a computer the videodisk becomes interactive and, hence, much more powerful pedagogically, and so does the computer.

At least that is the promise. NSF and other Federal agencies have already supported some R & D on the instructional use of interactive videodisks, as has private industry. But the pace has been much too leisurely, I believe, given the great potential of this new technology and the crises in the schools. Therefore, I strongly recommend that the Federal investment in videodisk R & D be dramatically increased, even, if necessary, at the expense of R & D on the computer as a solo learning tool. The point is to use government resources to help the schools leapfrog into the future, instead of letting them continue to drag along always decades behind the state of the art technologically.

3. THE FEDERAL ROLE IN THE DEVELOPMENT OF INSTRUCTIONAL MATERIALS--COMPUTER OR OTHERWISE--SHOULD BE TO PROMOTE INNOVATION AND DIVERSITY.

In the case of school learning materials, print and electronic, market forces tend, unfortunately, to favor uniformity over diversity. It seems that the publishers and producers imitate each other, playing follow-the-leader and trying to develop a product like, but better than, the books and programs that sell best. They also rely on market surveys, and such surveys generally show that teachers favor something like what they are already familiar with. Unlike the consumer goods market, volume is not great enough to invite very much risk-taking; and unlike certain technical markets, the per unit profit margin must be kept small.

All of this is understandable, but the net result is that risk capital is not readily available for the development of novel materials. This is all the more true in the case of computer programs, since it turns out to be extremely difficult to protect them from pirating. Yet what the education enterprise needs is a very large array of different materials--different in content, level, organization, style, purpose--from which to select. This suggests that the bills before you might usefully be modified to make certain that R & D funds are available to underwrite the creation of computer and interactive videodisk materials that are different from those being developed commercially, and that are state of the art. In particular there should be support for creative groups to develop such materials for the following educational purposes.

o Analytical thinking. As Alfred Bork and his colleagues at the Irvine Educational Technology Center have shown, it is possible to develop computer programs that engage the learner in reasoning, analysis and cognitive processes that go beyond mere recall. Such intellectual skills can be valuable for a lifetime, but they are not easily taught. The computer can be a uniquely powerful tool teaching those skills, but only if inventive programs are created.

o Teacher training. The computer, and especially the computerized videodisk, can become a key resource in the continuous up-dating of teachers. Just as they can help them locate resources and manage their classrooms, so too can they be used for learning new content and new techniques of teaching. To date, little has been done to realize this potential, which is surprising in the light of the acknowledged need for continuous in-service training for teachers.

o Testing. Teacher-made and commercial examinations are of limited power as diagnostic instruments. This is due to their emphasis on memory rather than understanding, and because practical considerations favor so-called objective tests. A good oral examination by a knowledgeable teacher is probably the best technique we have had for assessing both understanding and reasoning: since it is interactive, successive questions can be related to a student's previous responses. Now computers can make it possible to approximate such a line of questioning. Moreover, the interactive videodisk makes it possible to structure an examination around the visual portrayal of natural phenomena and situations. Potentially, this new technology can arm teachers with an effective new tool for assessing the progress of students, one that cannot be duplicated by paper-and-pencil tests.

o Career guidance. Students are dependent upon parents, teachers, counselors, and librarians for information about different lines of work--what it takes to get in them, where you can go to study for this or that profession, what the work is like, and so forth. The trouble is that none of those persons can have knowledge enough, and even the library collection on careers is incomplete in most schools. And anyway, youngsters often are unable to ask questions about professions they have never heard of. But the computer, being interactive, patient, and capable of manipulating huge databases, ought to be able to help a student explore a range of possibilities, and do so in a way that is interesting and neutral. The interactive videodisk offers an intriguing chance to enrich the computer-guided career exploration with relevant visual and oral material.

The context of the computer bills and of my call for the encouragement of diversity has been the personal computer. It is not clear, however, that education ought to confine itself to that alone, for it may very well turn out that for many educational purposes, central minicomputers will be needed. There is nothing to be gained by a single-minded or doctrinaire commitment to the personal computer as the educational instrument of choice. Government resource should be used to test various possibilities.

4. THE FEDERAL GOVERNMENT SHOULD ESTABLISH AN INDEPENDENT CORPORATION TO DESIGN, BUILD AND MAINTAIN A MODERN EDUCATIONAL TELECOMMUNICATIONS SYSTEM THAT EFFECTIVELY LINKS ALL SCHOOLS AND COLLEGES IN THE NATION TO SOURCES OF CREATIVE AUDIOVISUAL LEARNING MATERIALS.

There are creative individuals all over the country capable of making excellent filmed and videotaped instructional materials. Indeed, many of them do just that when given support. They are located in universities, museums, public television stations, government agencies, and in profit-making and nonprofit organizations. Foundations, government and industry might be willing to sponsor more such creative work in behalf of education if it were certain that the resulting materials actually reached the schools.

But that is precisely the difficulty: there is no nationwide telecommunications system dedicated solely to the schools and colleges. There are bits and pieces, here and there, but nothing that is technologically comprehensive and up-to-date. We have failed to apply powerful design principles and to exert our full creativity in the building of an effective electronic delivery system for education. It is not too late to begin.

Typically in education, we notice new technologies only after they have been around awhile serving other purposes (usually entertainment and advertising). Then we ask, how might we apply that technology--television or whatever--to the improvement of teaching? I am suggesting that we now try to move out ahead of the game by instead asking: Given the current and developing capabilities of all communications and information technologies, how can we design and install an effective nationwide educational telecommunications system? Such a system would probably involve the use of satellite and cable transmission, ground stations and off-the-air video copiers in every school and college, video players and computers in every classroom, networking, shared databases, and more besides. The system would be devoted exclusively to the educational needs of students and their parents, teachers and administrators, and others in the business of education.

To design, build, maintain and operate such a system, I recommend that you consider establishing a National Educational Telecommunications Corporation. This corporation would be concerned only with the distribution of non-book learning materials to schools and colleges (at no cost to the institutions or students); it would be prohibited from producing or commissioning the production of any materials. In this regard it would be different from the corporation proposed in H.R. 4628.

While I believe that NSF and other federal agencies can and should promote the development of computer and other kinds of experimental learning materials, as suggested above, I am not convinced that it is either necessary or wise to create a new entity to become, essentially, a publisher of educational software. Once an effective delivery system exists, a diverse array of materials from multiple sources could be channeled through it.

Perhaps an analogy will help clarify what I have in mind. I refer to the Interstate highway system. That system was made possible by the direction and capital of the Federal government; it never could have evolved from the accidental joining of the separate streets and highways being built independently by the towns, counties and states. As you recall, that tremendous investment in our "infrastructure" was justified in terms of national security needs. The agency responsible for that transportation delivery system, of course, had no part in determining what goods and vehicles would use it. One result of the system, surely, was greater diversity in the lives of many Americans. I am proposing that we institute something similar for education: Federal capital and direction in the building of an infrastructure for distributing certain kinds of learning materials, justified in terms of national educational needs, and aimed at increasing the variety and scope of materials available to schools.

CONCLUSION

Computers in any numbers, with or without good software, cannot alone solve our most pressing educational problems, any more than did television, with and without good programs. But it does offer us a fresh opportunity to exploit the power of communications and information technologies in behalf of better learning, perhaps even as a force for structural reform.

But nothing of the sort will happen spontaneously. It will take, among other things, thoughtful and substantial Federal leadership. That is why your consideration of H.R. 3750 and H.R. 4628 is so timely. Together the bills contain many important provisions, such as those calling for increased R & D and teacher institutes relating to the educational use of computers. The thrust of my remarks, however, has been to recommend that you modify the bills:

o To require sophisticated planning at every level in order to clarify goals, realize economy and coordination, and insure equity in the access to this new technology;

o To accelerate the process of technological modernization of education by including provisions for R & D on the use of combined video and computer technologies.

o To provide funding for the development of computers and computer software, and videodisks and videodisk software, in a way that promotes innovation and diversity, and that emphasizes the use of technology to help teach analytical thinking.

o To authorize the establishment of an independent corporation to design, build, operate and maintain a nationwide delivery system that utilizes the most advanced information and communications technologies to provide direct access to effective audiovisual and electronic educational materials by all schools, colleges, libraries and other places where learning takes place.

In short: it is time to MODERNIZE the schools by exploiting all communications and information technologies; it is time to PLAN for fundamental reform in education, even as we modernize it technologically; and it is time to INVEST in the modernization and reform of public education.

BRIEF BIOGRAPHY:

F. James Rutherford

Currently Chief Education Officer of the American Association for the Advancement of Science, James Rutherford served as Assistant Director of Science Education of the National Science Foundation before becoming the first Assistant Secretary for Research and Improvement in the newly created Department of Education. Prior to his federal appointments, Dr. Rutherford was professor of science education, head of the division of education and director of Project City Science at New York University, where he went after serving on the faculty of Harvard University and directing Harvard Project Physics. He has also been a high school science teacher, written and spoken extensively on issues in science education and served as a consultant on science education in many countries.

Mr. **Brown**. Thank you. Is it possible you have become a hopeless idealist since you left Government?

Dr. **Rutherford**. No, something worse than that probably happened.

Mr. **Brown**. The challenge to reform education is one which is made fairly often. I recall a conversation I had some time ago with Dr. Goodlad who is dean of the School of Education at UCLA. He said he spent a lifetime trying to train teachers to teach in the most effective possible way, and after they got out into the local school districts, they forgot everything they learned, mainly because of the influence of the local situation, having to deal with local school boards, administrators who were set in their ways, and so on.

Do you have an answer to how we can leap frog education in the way you suggest in light of this experience of what seems to be fairly common in our best teacher training institutions?

Dr. **Rutherford**. No. I have not, Mr. Brown. You know the situation out there is that lots of things have to be done. Unfortunately, they are all necessary.

I do think, however—meaning, of course, if we reform the curriculum but don't reform the teachers, it doesn't work. If we create modern, new teachers, then they go into a system that won't accept them or reject them, it doesn't work.

I don't think that has been solved. Except to say that the effort at reform so far has been disorderly.

It is Dr. Goodlad doing his kind of thing, and others of us doing something. But never in concert, never with a common goal, a common vision. So it is hard to get it to fit in.

We would have known if we had been working together that you have to work on the system, and offer it some advantage for changing, accepting new teachers.

I think that the technologies may provide some leverage. And that is one of the things that interests me about them. That in the process—I think you can sell the idea to the school and college people that you have to modernize, if they think it is not going to cause them too much grief, it might even help.

In the process of trying to build a whole system as opposed to this piecemeal business, I think it would force the school people into a situation where they would have to deal with one of the fundamental reform questions.

That may be wishful thinking. But not much else has worked.

Mr. **Brown**. May I ask your two colleagues to comment on this radical hypothesis you are making. Dr. Turkle, you are a sociologist. You understand the problems of social change happening rapidly.

Do you have any suggestions about how Dr. Rutherford's proposal could be accomplished?

Dr. **Turkle**. Well, one comment I have about the proposal is that for me, I guess for my taste at the moment, it focuses a little bit too much on the technology, a little bit too much on the computers and not quite enough, I think, on the computers and the people.

What we have now is quite exciting, and the changes that it makes in the sociology of the classroom, and the kinds of excitement that students have about learning, and the kinds of students, as I have tried to suggest, that can get involved in learning about formal systems, mathematics, thinking, a certain kind of thinking as was suggested by another member of the panel, is already quite exciting.

And one of the stumbling blocks is really not knowing enough about how to even exploit what really is a kind of grass roots movement that is starting even now.

I am not against really a global stepping back and looking into the future and leap frogging and taking this terribly seriously. But I guess I feel that I would not want that to be obscure, or the kind of immensity of this kind of project to obscure that there are some things that can be done now really with the materials and the teachers and the students and the computers that we have now if we would worry a little bit less about how much information, new information, the teacher needs to get, and a little more about how the teacher needs to learn to relax and to accept that this is a domain in which the student may know—it is one of the few domains in which students and teachers are really learning together, where the teacher really is not kind of one who knows the most and is imparting that into the student as a vessel, where there is more chance for collaboration that can be exciting as well as threatening.

These are—I called it consciousness raising. I didn't mean that lightly. These are things that could really improve the quality of I think what we are doing with computers and children today.

And those shouldn't be, I don't know, sort of cast aside as not important and too trivial because they don't do this stepping back and making the larger plan.

So I guess I would like to just——

Dr. **Rutherford**. Could I comment on that? I think that is an excellent example—it will happen at MIT and a few places. But unless there is some local planning, that is not how computers will be used.

I have been in hundreds of schools, and you just don't see that, because they don't plan for it. I am not talking also globally.

I say you have to look at a system, as you look at the school building, and say what do we need to do, what are the kinds of things we need to do, how can we get teachers to understand these kinds of things.

And I don't think that happens accidentally. So I guess I am arguing if there will be Federal money, State money, the pressure has to be started locally, and say you don't get these things until you have gotten together, find out about it, and what you plan to do.

Dr. **Turkle**. I agree with the planning and the local and decentralization. I guess I think it is a problem of computers and people, not just of computers.

Mr. **Brown**. I think Dr. Rutherford understands that technology isn't necessarily the answer, despite all its marvels. I tend to agree with him that we do have a tremendous opportunity here to make use of this whole panoply of technology.

I like this great system building kind of approach that you take, but we also have to look at how you do it incremently. We are not going to do it all at once. And we have some examples of systems similar to this that have taken many years to develop. Going through my mind is the National Library of Medicine, which has become a part of almost a global system of providing data on research and health and medicine and so on.

It is available as a learning tool for doctors. It is available in many ways, through regional institutions and local institutions, but it has taken many years to build it up to the present status.

Dr. **Rutherford**. When I speak of reform, I am talking about a quarter of a century. I think part of our problem is we believe we can do something in a year or two. Well, 10 years is the minimum time I think of the possibiity of change in schools. So we have to—but we don't keep with something.

Now, how to get started. I suggested at one time, and I didn't get very far, that a way to start in would be to take a special population. I had in mind the children of minority—of migrant workers. Now, we know pretty much where those migrant families are, how they move through the great chains, in doing the work that is so important for all of us. But their children suffer. And the schools really are not able to accommodate them because they move.

They come in in the middle of the year. We know all of that, but you know with a couple of satellites, some central computers, some PC's in some special buildings, some adult help, those children could move from day to day and at least through this technology with what we already know and we already have, we could have a little system there that would keep track of each child at least in learning the basics of arithmetic and English and expression.

Now, that would not be so expensive. And that is the sort of thing the Department of Education ought to be doing as a way of beginning to build up a system, to learn how to do those sorts of things, to help that population and then from that think in larger terms. I must say I don't see anything like that happening. But I think it in principle could.

Mr. **Brown**. Do you have any comments, Dr. Bell?

Dr. **Bell**. Yes. I think what Dr. Rutherford is conceptualizing is quite good. And in fact I believe that that was the vision of the PLATO project, when it first was organized to some extent. The vision of PLATO was to have all of the technologies—the satellites, what you are proposing—and with the advent of microcomputers, it seems to me that Plato moved back to better and more efficient computer assisted instruction rather than going on to video discs and so on.

So I think education is an extremely conservative activity and we seem to be able to take the best of the technology and put it to some very interesting trivial uses. And I don't know how to get out of that cycle, but PLATO, I guess, has been around for at least 15 years. Maybe if you get involved for the next 10 years, it can be turned around in the direction that it was headed originally.

Mr. **Brown**. There is a tendency for new technologies to become trivialized. It has happened with radio and television. It has happened with other technologies.

Is there any guarantee that it wouldn't happen with this system you are talking about?

Dr. **Rutherford**. I think it will be trivialized. Our only chance is if we seize it early and try to build in some learning and educational uses. Sure we lost on radio and television. We decided the purpose was to sell goods. It could have been something else. It could have been propaganda. That would have been worse, but it wasn't as educational as it might have been.

Now we have another chance, particularly with the videodisc, the intelligence videodisc—the interactive videodisc. We have another chance and we still have a chance to capture—this is why I prefer not to just talk about computers.

It was last evening I told someone here coming over there was a marvelous two-part film on channel 26 on George Balanchine. It will be shown once or twice and disappear. Every child, 10 years, a quarter of a century, should have a chance to have these insights into one of the most famous people on the 20th century.

Well, if we had—we have all the technology that would make it possible for that simply to have been pushed out in the middle of the night, capture it at each school building, put on a videotape and available for enternity, for use in that school. So some things we could do if we had the will. Others of them, we are out on the edge, state of the art.

I think the advantage is to try to get there quickly so that the things get looked at in this educational context instead of some others we are likely to see.

Mr. **Brown**. Well, going around the country as I do, I notice there are more and more hotels, motels, and other things that have their own dish and they are receiving almost unlimited television coverage. And most of them now have interactive conferencing capabilities, which is ideal for educational purposes. Businessmen can have a national trading session without going out of their home city by just making use of these capabilities.

It seems to me something like that could easily be done for education if the vision and the will were there to do it, which is what you are suggesting. But the vision and the will are not there to do it at the present time.

Does this legislation offer any possibility of inciting that kind of vision and will or would it be a step in that direction?

Dr. **Rutherford**. Well, I think it is a step. And it does have enough in it, it touches lots of bases. So it does have training elements. It talks about planning, the software and the hardware. The elements are there. I suppose what one might think of using it for is to articulate a somewhat larger goal than simply using computers in schools and perhaps emphasizing more than is in there now the idea of planning for the redesign and reconstruction of the schools.

Otherwise, I think the bill tends to come out looking like a grab bag of good things, but which once again may not quite add up.

Mr. **Brown**. I think each of you have agreed to the fact, or on the need, for additional research capability in this area. Dr. Turkle, you mentioned that. I think you implied, if not stated, in the statement the need for additional research—although you may not all have the same research agendas, am I correct in this interpretation of what you are saying?

Dr. **Turkle**. I certainly am saying that. I think I am trying to stress even more that this research should be really about computers and people. And I think that if we knew more about how different kinds of—just take the case of children, of course, although children are not the only people involved in education. How different kinds of children exploit the computer or get stuck with the computer in different kinds of ways, given who they are as people.

If we understood the processes better and the fit between computation and the individual, if we understood all of that better, then we would be in a position not just to exploit the instrumental computer, what the computer can do for us.

But I guess what I would call the subjective computer, the computer as it can profoundly influence the way we think, the way we reason, the way we are able to manipulate information and work with it in more creative ways. Those are my goals for the computer revolution and I think that those goals require fundamental research really on people as well as machines.

Dr. RUTHERFORD. I would support that. But I would say I think there is the nature of research that we don't quite know where the most important knowledge is going to come from. So we need a much stronger and continued program of basic research. And I think NSF is doing some of this and ought to do more. And it should be the entire realm, from research on neuropsychology and how cells learn to how people learn, things related to language and language systems, continued research on how electronic systems can respond to logic, and so forth.

So that there is a broad range of basic and applied research going on, and some of it have applied. That is one of the troubles in educational research. It has been to do too much in the NT University laboratories, too little of the NT places where the learners are.

I think that can be remedied. It is worth noting in that respect that the NSF and the National Institute of Education, both of which have done very respectable work in supporting educational research, backed down a few years ago and are now doing a little more, but should be. I think this bill might be used among others to cause an acceleration of their entry back into the support of first rate R&D.

Mr. BROWN. My personal feeling, and I tend to reflect that more than anything else in my dialog with you, is that we probably need to find some system which will include both the research component and the technological systems component that you are talking about, Dr. Rutherford, which could help us expand the process of research into each of the local school districts, maybe with the theme of what is the best way to bring about the kinds of educational changes that you have proposed here.

I can envision, well, say, perhaps a regional demonstration steered around maybe a consortium of educational research institutions that would try and bring a research—try to create a research process that would permeate every part of the region and see what could be accomplished there using this marvelous telecommunication satellite capability, interactive and so forth.

But I am at a loss to know how we are going to get the initial steps undertaken here, how we are going to fund something of that sort. Maybe this would be a beginning, I am not sure, but there still isn't the vision of the kind of changes that we need that you are referring to in your own remarks.

This has been a very stimulating exchange for me. I have a number of other questions that we might want to propound to you, but in light of the time, I think we will call the hearing to a close. I do appreciate your contributions very much and I hope that we can move forward in the direction that has been hinted at here.

With that, the subcommittee will adjourn for the day and have a good afternon, Doctor.

Dr. RUTHERFORD. Thank you.

[Whereupon, at 3:20 p.m., the subcommittee adjourned.]

APPENDIX

ADDITIONAL STATEMENTS SUBMITTED FOR THE RECORD

Association of American Publishers, Inc.

2005 Massachusetts Avenue, N.W.
Washington, D.C. 20036
Telephone 202 232-3335

Testimony of the Association of American Publishers
Submitted to the House Subcommittee on Science,
Research and Technology on
HR 1134 and HR 4628

June 5 ,1984

The Association of American Publishers (AAP) is the general association of book publishers in the United States. It comprises Professional and Scholarly Publishing; Higher Education; International; Direct Marketing/Book Club; School and General Trade divisions. Our some 300 member publishing houses produce the vast majority of the general trade, educational, reference, professional and religious books published in this country and found in the nation's libraries as well as considerable related audio-visual material. Our members also publish a great volume of computer software for the educational, professional and consumer markets.

Undue Federal Influence

A long-time cornerstone of all Federal aid to education programs is what is now Sec. 432 of the General Education Provisions Act:

> Prohibition Against Federal Control of Education
>
> Sec. 432. *No provision of any applicable program shall be construed to authorize any department, agency, officer, or employee of the United States to exercise any direction, supervision, or control over the curriculum, program of instruction administration, or personnel of any educational institution, school, or school system, or over the selection of library resources, textbooks, or other printed or published instructional materials by any educational institution or school system*, or to require the assignment or transportation of students or teachers in order to overcome racial imbalance. [Emphasis added]

This provision had its origins almost three decades ago in the National Defense Education Act at which time it was known as the Morse-Taft Amendment, indicative of the agreement between liberal and conservatives that Federal aid to education should not mean Federal influence or control of local education practices.

Similar provisions are found in the Library Services and Construction Act (Sec. 2(b)), the Department of Education Organization Act (Sec. 103(b)), and the Job Training Partnership Act (Sec. 145).

Federal evaluation of software or other instructional materials would clearly violate this well-established hands-off mandate. What value judgments would the evaluators apply? And how would those value judgments change from administration to administration? What influence would such evaluations have on the adoption by local educational agencies of one item versus another? We strongly urge that no provision for evaluation of software or other instructional materials be included in any bill reported by the committee.

Also, the National Educational Software Corporation, which would be established by HR 4628, represents such undue Federal influence by its development of criteria for the selection of educational software (such criteria now being a function of State and local educational agencies) and by its ability to favorably finance those companies which fulfill its requirements.

Instructional Materials

Any legislation reported by the committee should recognize that the new technology requires not only discs, chips and other similar materials and equipment but also requires complementary printed instructional materials, such as textbooks, manuals and workbooks. One must contemplate not only the materials used in the computer itself but also the necessary complementary materials referred to.

The October, 1982 report of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology, "Today's Problems; Tomorrow's Crises", after recounting the teaching potential of the new technology, adds a cautionary note: "However, computer software is generally inadequate, and the full potential of these technologies for instruction has received little attention."

The Office of Technology Assessment, in its report, "Information Technology and Its Impact on American Education", profers a similar conclusion: "OTA found that the most-often cited barrier to current educational use of technology was the lack of adequate educational software."

The cost of developing instructional materials to be used with the new technology is very high. Some companies have invested as much as $1.5 million in their computer software programs. Small companies are consequently often discouraged from entering the field. In addition, larger firms are reluctant to risk substantial sums in enrollment areas which have a relatively small number of students.

A principal conclusion of the January 1981 Report of the U.S. Department of Education Task Force on Learning and Electronic Technology stated:

> Many private sector companies have made tentative forays into developing technological products and services for education. The outlook for future efforts to expand the impact is not bright, largely because education systems provide few significant incentives to private-sector entrepreneurship in this area.

This finding impelled the following recommendation:

> The Department should provide incentives to encourage private-sector/university combined efforts to develop exemplary "high quality" software for computers and videodiscs. This should be done in cooperation with school districts and state education agencies that elect to participate in such ventures. The purpose is to get all involved in making the trade-offs that will be needed to successfully implement the new technologies in instructional settings.

We also cite the December, 1982 policy paper of the Council of Chief State School Officers, "Need for a New 'National Defense Education Act'" which stated:

> The fields of mathematics and science are particularly vulnerable to the rapid obsolescence of instructional materials. Allowable expenditures under any federal program should include assistance to school districts to maintain reasonably up-to-date texts and library resources. School districts and states could use funding to meet their needs, including at least:
>
> - new science and math sequences which match the stages of children's intellectual development;

- updated curricula which accommodate technological and social changes;
- new mathematics and science equipment, including computer hardware and software.

In the light of the foregoing we urge that prime emphasis be given to the development of high-quality courseware, embodying both the latest knowledge and techniques, and involving, as the Department of Education Task Force report suggests, the combined efforts of the private sector and the academic community.

Private Sector Participation

Congress recognized the importance of private sector participation in the development of instructional materials and curricula when in 1978 it added subsection (c) to Sec. 426 of the General Education Provisions Act (GEPA), the law which now applies to all Department of Education programs. The pertinent portion of that subsection reads as follows:

> (c) In awarding contracts and grants for the development of curricula or instructional materials, the Commissioner and the Director of the National Institute of Education shall--
>
> (1) encourage applicants to assure that such curricula or instructional materials will be developed in a manner conducive to dissemination through continuing consultations with publishers, personnel of State and local educational agencies, teachers, administrators, community representatives, and other individuals experienced in such dissemination;

This private sector participation factor is not adequately recognized in the pending legislation. It is a matter of good sense that any measure adopted by the committee should reflect this mandate for private sector participation for it is based on hard experience. Too often have curricula and materials been developed with Federal assistance which now rest undisturbed in college libraries or academic files but are unused in the schoolroom. Textbook publishers have valuable knowledge of adoption procedures, schoolroom requirements, teacher problems and the myriad of other factors which go into the development and subsequent use of successful instructional materials and curricula.

In addition, just as the private sector has a recognized and proper role in the development of instructional materials and curricula, so it also has a role in the training of teachers in the use of such instructional materials and curricula. As a matter of long practice, publishers provide in-service training to teachers in the use of texts and workbooks which the school system has obtained from them. Such expertise should continue to be utilized.

The National Educational Software Corporation contemplated by HR 4628 is antithetical to this concept of private sector participation for it establishes with taxpayer funds an entity designed to compete with the private sector with the very funds they pay in taxes. While competition is the essence of private sector success, competition financed, nurtured and given a special cachet by the Federal Government assuredly is not.

Basic Research

The Office of Technology Assessment report found that "to make the most effective use of technology, there was a need for R&D in learning strategies and cognitive development, methods for the production of effective and economical curricular software, and the long-term psychological and cognitive impacts of technology-based education. It is worthy to note that, based on the foregoing, OTA urges that "Congress should consider policies to:

"(1) directly support R&D in these areas,

"(2) encourage private sector investment from both foundations and industry, or

"(3) encourage a combination of both by using Federal funding to leverage private investment."

Any legislation adopted by the committee should require the basic research urged by the OTC report.

Chief among the items to be mandated should be:

1. Research on the instructional uses of the new technology.
2. Research on what kinds of instructional materials should be developed to work with the new technology.
3. Basic research on how students learn through use of the new technology.
4. Research on how curricula can best be presented using the new technology and complementary instructional materials.

This research is in keeping with the intent of Congress as set forth in Section 405(a)(2) of the General Education Provisions Act which states that "The Congress further declares it to be the policy of the United States to...help to solve or to alleviate the problems of, and promote the reform and renewal of American education..." and to "strengthen the scientific and technological foundations of education...."

Copyright

A principal detriment to the development of computer software has been copyright violation. The ease with which software can be duplicated and used in the classroom plus the ignorance of many educators of the copyright laws has made this a major problem.

If the committee should adopt legislation providing assistance to educational agencies in the acquisition of software, either through purchase or loan, such legislation should make certain that those receiving such assistance are sensitive to the nation's copyright laws and will follow them. Such a sensitivity, for example, should be reflected in any plans the bill might require educational agencies to submit.

In this connection, we invite the committee's attention to the policy statement adopted by the International Council for Computers in Education, a consortium of groups from six nations, including twenty-five U.S. state and national organizations; and 14,000 individual teachers of computer literacy and computer science:

> Educators need to face the legal and ethical issues involved in copyright laws and publisher license agreements and must accept the responsibility for enforcing adherence to those laws and agreements. Budget constraints do not excuse illegal use of software.
>
> Educators should be prepared to provide software developers or their agents with a district-level approved written policy statement including as a minimum:
>
> 1. A clear requirement that copyright laws and publisher license agreements be observed;
> 2. A statement making teachers who use school equipment responsible for taking all reasonable precautions to prevent copying or the use of unauthorized copies on school equipment;
> 3. An explanation of the steps taken to prevent unauthorized copying or the use of unauthorized copies on school equipment;
> 4. A designation of who is authorized to sign software license agreements for the school (or district);
> 5. A designation at the school site level of who is responsible for enforcing the terms of the district policy and terms of licensing agreements;
> 6. A statement indicating teacher responsibility for educating students about the legal, ethical and practical problems caused by illegal use of software.

We urge that the provisions of the policy statement advanced by the Council be a part of the established policy of any educational agency or other entity utilizing Federal funds for software and that potential recipients must attest to having such an established policy.

Other Provisions

Federal education aid programs traditionally include a provision that Federal funds should supplement, not supplant, local and state expenditures. This has the effect that the Federal funds provide education aid, not mere financial aid. Such a provision should be included in any bill reported by the committee.

Similarly, a maintenance of effort provision should be included. If a deficit-burdened Federal Government is expected to expend scarce financial resources to assist local and state education efforts, then the least that should be expected of such states and localities is that they maintain their own level of expenditures.

Summary

Any legislation reported by the committee should be complementary to, and not duplicative of, the Emergency Mathematics and Science Education and Jobs Act (HR 1310), which passed the House on March 2, 1983; the Advanced Technology Foundation Act, HR 4361, which was reported by the House Committee on Banking, Finance and Urban Affairs on April 24, 1984; and Chapter 2 of the Education Consolidation and Improvement Act of 1981.

The concept of HR 3750 has merit. However, to best achieve the purposes for which the legislation is intended we urge in our testimony that (1) the bill be amended to eliminate provisions for evaluation of instructional materials, (2) the basic research elements we outlined be included, (3) that there be adequate provision for private sector participation, (4) that the copyright protection provisions we suggested be included, and (5) that "supplement, not supplant" and maintenance of effort provisions be added.

As for HR 4628, we find that measure objectionable because of the factors of (1) undue Federal influence on the content and choice of instructional materials and (2) Federal competition with the taxpaying private sector.

Statement
# of the
Association of Data Processing Service Organizations
on H. R. 3750, the
Computer Literacy Act

The Association of Data processing Service Organizations, Inc. ("ADAPSO") appreciates this opportunity to express its views and reservations on H.R. 3750, the Computer Literacy Act of 1984.

ADAPSO is the trade association of the computer software and services industry. Its more than 670 member companies and industry provide the public with a wide range of computer software and services including local and remote data processing services, software for mainframe, mini, and microcomputers, professional systems analysis, design and programming services, and integrated hardware/software systems.

Virtually the entire ADAPSO membership of almost 700 private sector firms has a stake in educating future generations in the operation of computers. Our nation is caught up in an "information revolution", and computer technology is changing the way we live, work, and play. Our work force is changing course as a result of the "information revolution". High technology jobs are gradually replacing many traditional manufacturing positions. Unfortunately, our nation has not yet gained widespread computer literacy. We are not adequately training our young people to meet the responsibilities and needs of a more service oriented economy.

One reason for the failure to make young people more "computer literate" is the lack of computer equipment in many schools. Some industry experts suspect that we are dividing our society into the "haves" and "have nots". Schools with computers can teach their students the necessary skills to succeed. Schools without computers, however, cannot train their students for high technology jobs. Therefore, we may actually be educating a subclass of students who will be permanently unemployable.

The obvious solution is to place a wide variety of state of the art computer equipment plus the necessary software and services to make this equipment productive in as many elementary and secondary schools as possible. Schools can well be expected to have differing requirements with respect to computer hardware. Along with the computer equipment, schools need extensive software libraries, maintenance and update agreements, training instructors, and local technical guidance. In other words, they should have complete systems tailored to the needs of the schools and their students.

H.R. 3750 has computer literacy as its goal, but it also contains several flaws which work to defeat this goal or otherwise create serious problems for the software industry. This legislation fails to recognize that the key to computer literacy rests with software, and that massive purchases of hardware alone will not enhance students' education. Title I of H.R. 3750 authorizes the funding for 1.3 million microcomputers, but provides no funds for software purchases. The school systems receiving hardware grants will still face a substantial bill for software, without which the computers are essentially useless. Since school funds are always scarce, we fear that teachers may look to copying software packages to solve the dilemma. This poses two problems, each equally important. First, while many software packages, at present, can be copied with relative ease, software is protected under U. S. copyright laws, and teachers will be opening themselves to tremendous legal liability. The risk is particularly great since many software developers are beginning to pursue their copyrights with vigor. Second, no software developer will maintain or update a pirated program. School systems will find themselves very quickly without the most up-to-date tools with which to teach their students. H.R. 3750 should be amended to allow for purchases of software and maintenance and support services.

In Title II: Teacher Training Institutes, ADAPSO commends the sponsors of the bill for recognizing that teacher training is an important part of computer education. We are concerned, however, because the provision limits participation in teacher training institutes to "nonprofit science and engineering organizations, museums, centers, state educational agencies and institutions of higher education (including community colleges). . . ." (Sec. 201(a)). Many ADAPSO member firms provide training to the private and public sector in the use of microcomputers and associated software. The most advanced training techniques are being used by these firms; they are professional and reasonably priced. H.R. 3750, as presently drafted, would arbitrarily exclude all private sector firms, shutting them out of an important marketplace. No reason is given in the committee report for excluding these highly innovative companies which are primarily small businesses. Further, it enhances the competitive advantage of nonprofit entities against that of tax paying private sector firms. ADAPSO believes the emphasis should be on providing the best training on an equal basis regardless of the source, nonprofit or private sector firm.

ADAPSO respectfully suggests that H.R. 3750 be amended to include the private sector. A similar provision in Title III excludes for-profit companies from participating in the grant program established by the National Science Foundation to "conduct, assist, foster research and experimentation on, and dissemination of, models of instruction in the operation and use of computers." (Sec. 302(a)). The private sector has been working in this field since the development of the microcomputer. To exclude them now makes no sense from a technological point of view and could cause economic harm to small businesses, surely a result the drafters of H.R. 3750 could not have intended.

ADAPSO and its membership oppose Title III of H.R. 3750, Information Dissemination and Evaluation, in its entirety. The report prepared by the Education and Labor Committee accompanying H.R. 3750 states that an "educational software problem" exists and that the federal government should, therefore, develop model educational software. ADAPSO agrees neither with the Committee's premise nor its conclusion. It is true that the educational software market is a new one, and that the number of microcomputers in schools is still relatively low. The numbers are growing steadily, however, and a number of innovative firms are producing educational software. It is likely that as the number of microcomputers in schools grows, other firms will seize the opportunity to produce high quality software in sufficient variety to fill any gap. It is extremely difficult, however, for small companies to fund the necessary research and development for new products when faced with a marketplace already preempted by the federal government. The U.S. software industry has repeatedly demonstrated its ability to provide the most innovative and low cost software products. It is no coincidence that the U. S. leads the world in software technology. In light of the U. S. software industry's proven track record, it is especially hard to understand why the authors of the bill believe the federal government should control the development of model educational software.

As a general principle ADAPSO opposes government competition with the private sector. Our economic system is premised on the belief that innovation, productivity and low cost to the consumer will be enhanced only where there are many enterprises vigorously competing in an open marketplace. We are concerned that should the National Institute of Education and the National Science Foundation interagency program succeed in writing model software, the resulting product will establish a de facto government standard—at the lowest possible level. This model software will bear the government's stamp of approval and have a great competitive advantage no matter what its quality. The interagency program also calls for the evaluation and dissemination of hardware and educational software which is already being performed, and adequately so, by the private sector.

ADAPSO shares the belief of Congress that U. S. students should have available the necessary tools to complete their education and to prepare for successful careers. ADAPSO believes this is crucial if America is to maintain its role as a technological world leader. We believe, however, that while the goal of H.R. 3750 - computer literacy - is extremely important, the bill as currently drafted, will not achieve its goal and will cause irreparable harm to the dynamic, highly innovative U. S. educational software and training industry.

Thank you very much for this opportunity to express our views on H.R. 3750.

OG/epb-060484

UNITED STATES DEPARTMENT OF EDUCATION
THE SECRETARY

JUN 27 1984

RECEIVED
JUN 29 1984
COMMITTEE ON SCIENCE
AND TECHNOLOGY

The Honorable Don Fuqua, Chairman
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

On June 19, 1984, the Subcommittee on Science, Research and Technology reported H.R. 3750, the Computer Literacy Act of 1984, and H.R. 4628, the National Educational Software Act, to the Science and Technology Committee. I understand that the full Committee will consider these bills next month.

As you may know, the Department of Education's views on these bills were presented to the Subcommittee on June 5 by Gary Bauer, Deputy Under Secretary for Planning, Budget, and Evaluation. His testimony before the Subcommittee, a copy of which is enclosed, stated the Administration's opposition to the proposed legislation.

H.R. 4628, the National Educational Software Act, would authorize $45 million over a three-year period to establish a National Educational Software Corporation which would provide investment capital for software projects and develop criteria for selecting educational computer software. The Department of Education and the National Science Foundation have sufficient authority to make seed money available for high risk software projects and have a long history of success in this field. With respect to authority for developing selection criteria for software, we believe that this is an activity that should not fall within Federal jurisdiction.

H.R. 3750, the Computer Literacy Act of 1984, would provide funds to local school districts to purchase computers, establish teacher training institutes and provide for the research, evaluation, and dissemination of computer hardware and software. Through Chapter 2 of the Education Consolidation and Improvement Act of 1981 (P.L. 97-35), many States are already purchasing computers and other instructional materials. Furthermore, the National Science Foundation is currently supporting teacher training institutes.

In addition to funds available under the block grant, the Department is supporting more than 200 computer related projects, one of which is the National Institute of Education's National Educational Technology Center. The Administration has

400 MARYLAND AVE., S.W. WASHINGTON, D.C. 20202

requested a $6 million increase in funds to NIE (part of which will be used for projects in technology) and additional increases have been requested for Chapter 2 and for the Secretary's Discretionary Fund under the Education Consolidation and Improvement Act of 1981 (P.L. 97-35), which could be used to support computer activities.

While the expressed goals of H.R. 3750 and H.R. 4628 are commendable, we oppose their enactment and urge you to vote against reporting them to the full Committee.

The Office of Management and Budget advises that there is no objection to the submission of this report and that enactment of H.R. 3750, and H.R. 4628 would not be consistent with the Administration's objectives.

Sincerely,

T. H. Bell

Enclosure

THE WHITE HOUSE
WASHINGTON

October 31, 1984

Dear Judd:

Per your request, I welcome the opportunity to make known my views on H.R. 4628, the National Educational Software Act of 1984. I stated my position on this bill in a May 10, 1984 letter to Chairman Carl Perkins, a copy of which is attached. My views on this proposal have since not changed. I hope this is helpful.

Yours truly,

G. A. Keyworth
Science Advisor to the President

The Honorable Judd Gregg
U.S. House of Representatives
Washington, D.C. 20515

Enclosure

cc: Doug Walgren

THE WHITE HOUSE
WASHINGTON

May 12, 1984

Dear Mr. Perkins:

Thank you for the opportunity to comment on H.R. 4628, the "National Educational Software Act of 1984." The bill would establish a government funded corporation, which would attempt to develop and distribute educationally useful computer software. We strongly oppose this bill.

H.R. 4628 is premised on the alleged current lack of educationally oriented computer software, and assumes that if this is a problem, then only a massive coordinated intervention by the Federal government can remedy it. We believe that both the premise and the assumption are wrong. Private software vendors have mushroomed overnight to supply business oriented programs as microcomputers have spread into offices. There is little reason to believe that a similar response will not occur as computers diffuse in our schools and colleges. Control Data Corporation has been selling interactive education programs, its "Plato" system, for several years, and many other vendors are now beginning to advertise educational packages available on their products (e.g. Texas Instruments).

The question of how to fully exploit the capabilities of computers in an educational environment has not yet been satisfactorily answered. Clearly, the solution requires the active involvement of at least practicing teachers, subject experts, computer scientists, and manufacturers. This is an area with enormous potential payoff for our society. However, the National Science Foundation has adequate authority to deal with this issue, and they are already beginning to receive some very exciting proposals for funding. We expect them to take an active leadership role in ensuring continued U.S. leadership in this area. H.R. 4628 would result in the diversion of resources and the imposition of a risk-averse government board. I strongly believe that it is exactly the wrong way to go.

Yours truly,

G A Keyworth

G. A. Keyworth
Science Advisor to the President

The Honorable Carl D. Perkins
U.S. House of Representatives
Washington, D.C. 20215

BEST COPY